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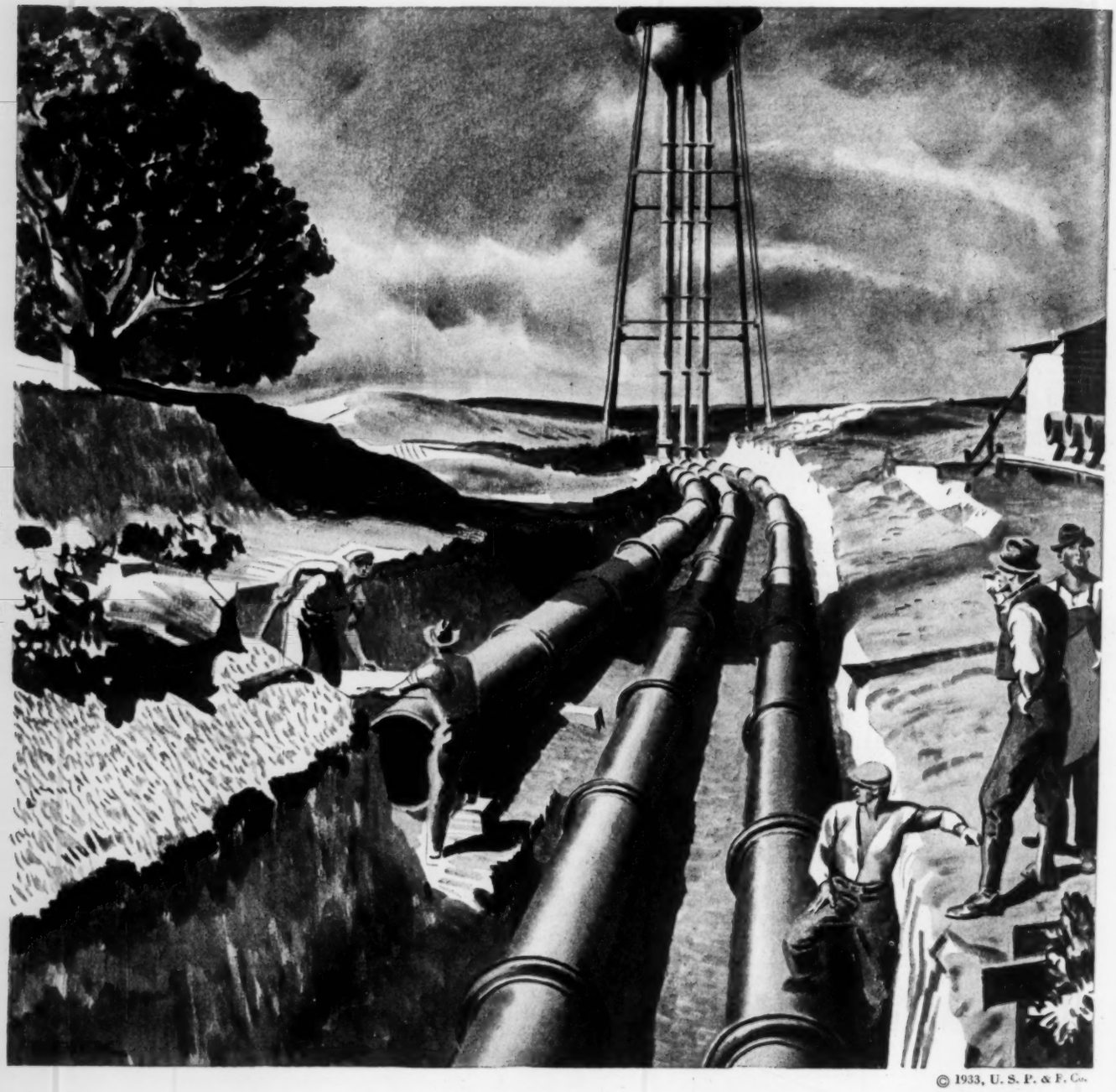

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VOLUME 3

NUMBER 8

Chicago Terminus of Lakes-to-Gulf Waterway

Conflict Between Land and Water Traffic at Bridge Crossings a Serious Problem

By DANIEL I. SULTAN *and* D. A. D. OGDEN
LIEUTENANT-COLONEL AND FIRST LIEUTENANT, RESPECTIVELY
CORPS OF ENGINEERS, U.S. ARMY, CHICAGO, ILL.

ON June 22, 1933, the Great Lakes and the Gulf of Mexico were officially joined together at Chicago when the completion of the 327-mile connection between Lake Michigan and the Mississippi River was celebrated. This connection, visioned by Jacques Marquette 260 years ago, affords a 9-ft channel by way of the Illinois River, the Illinois Waterway, the Chicago Drainage and Ship Canal, and the Chicago River. The latter winds its way through the heart of Chicago's business district, where heavy land and water traffic vie with each other at the frequent bridge crossings. Except for such barges as can pass under the closed bridges, traffic on the Chicago River is now almost impossible. With the added commerce from the Gulf, the conflict between land and water traffic will become absolutely intolerable.

The authors of this article, an abstract of the paper presented on June 29, 1933, before the Waterways Division at the Chicago Convention of the Society, point out the many advantages of improving the Calumet-Sag drainage canal to establish lake connections in the industrial district surrounding South Chicago, Ill., and Gary, Ind. This plan provides for the development of Lake Calumet into a great inland terminus and transfer point for the commerce conducted by lake, river, rail, and truck.

FIG. 1. THE INLAND WATERWAY SYSTEM OF THE UNITED STATES

GREATER Chicago, with its four million people, includes the very densely populated and highly industrialized area of metropolitan Chicago and adjacent municipalities in Illinois and Indiana. Railroads, highways, and a large fleet of Great Lakes steamers serve the locality. These excellent transportation facilities have developed the area into the most important collecting and distributing center in the Middle West, and have earned for Chicago the title of "the world's greatest railroad center." This represents a century of progress in empire-building.

Some locality near the foot of Lake Michigan was destined to be the site of a large city, but the exact location was determined by the natural advantages of water transportation routes. Father Marquette, the intrepid explorer, was also a good engineer. He recognized the importance of the easy portage across the divide separating the lakes from the interior rivers, and recommended that this natural route be improved. Chicago has always been a lake port. It is now a river port and the Great Lakes terminus of the entire inland waterway system. With the opening of the St. Lawrence to larger ocean vessels, Chicago will take its place among the great ocean ports of the world. It is destined to be the greatest transportation and industrial center of our country—perhaps of the world. It must not sacrifice these advantages. It must build and develop according to plans that will take advantage of its natural location, the artificial gifts resulting from the forethought and progressiveness of its people, and the sound policies of the National Government.

The waterways belong to the Nation. One glance at a map of these inland routes (Fig. 1) will show the possibilities of interstate trade by water. The people of Pittsburgh, the Twin Cities, Kansas City, St. Louis, Memphis, New Orleans, Mobile, Birmingham, Houston, and Galveston want to trade with Chicago and the lake cities. They want an adequate connection between the Great Lakes and their inland rivers. In developing the lake terminus of the Lakes-to-Gulf Waterway, the rights and desires of this entire central empire must be safeguarded.

There are five harbors on Lake Michigan within the area of greater Chicago, located as shown in Fig. 2. Chicago Harbor, which includes protected areas in Lake Michigan and the Chicago River, is closely hemmed in

by city parks and by extensive railroad yards. It is not susceptible of material enlargement except by filling in deep-water lake areas at great cost. Adjacent to the river is located the heart of downtown Chicago's very highly developed "Loop" district, which consists chiefly of office buildings, hotels, stores, and theaters. Calumet Harbor, usually referred to as "South Chicago Harbor," is similar to Chicago Harbor in that it consists of a protected area in the lake and about six miles of river improved for lake navigation. It serves the great industrial area of South Chicago. Indiana Harbor, six miles southeast of Calumet, is entirely artificial, and comprises a small outer harbor and a canal. It serves varied industries, principally steel and oil. Buffington Harbor is a private artificial harbor, located about $2\frac{1}{2}$ miles southeast of Indiana Harbor. It provides for the shipping of a large cement company. Gary Harbor is another private harbor, built by a large steel company for the service of its own and allied industries. All water commerce in these harbors is now lake commerce, and consists chiefly of iron ore, oil, cement, stone, grain, coal, sulfur, and automobiles moved via the Great Lakes.

Traffic carried in lake vessels on the Chicago River has fallen off steadily in the past forty years, but of late has tended to become stabilized through the increase in business carried by low-clearance vessels passing beneath the bridges in the closed position, which has to some extent offset the loss of traffic carried in masted vessels. In 1929, the last year of normal trade, the commerce on the river was less than 2,000,000 tons, of which only 675,000 tons was in lake vessels that could not adapt themselves to low-clearance bridges. The harbors at the mouth of the Calumet River and to the south are surrounded by industrial developments. Traffic through these harbors has grown rapidly and may be expected to continue to do so. The traffic through them in 1929 was: Calumet Harbor, 15,000,000 tons; Indiana Harbor, 7,500,000 tons; Gary Harbor, 8,800,000 tons; and Buffington Harbor, 1,300,000 tons.

The last step in the completion of the present connection with the inland rivers—the construction of the so-called "Illinois Waterway" from Utica to Lockport—was begun by the State of Illinois in 1920. It was financed with the proceeds from the sale of $20,000,000 worth of bonds. In 1931 the work was taken over by the United States for completion at a further cost of $7,500,000. Its channels have a minimum width of 200 ft and are 9 ft deep at extreme low water. A fall of 139 ft in 60 miles is overcome by five locks and dams, including the lock at Lockport. Locks are 600 ft long by 110 ft wide in the clear. From Lake Michigan to Lockport the distance is 36 miles; from Lake Michigan to the Mississippi River, 327 miles; from Lake Michigan to the Gulf, 1,630 miles. From Lockport south to the Gulf of Mexico, the route of the Lakes-to-Gulf Waterway is now fixed. The present problem is to decide the route between Lockport and Lake Michigan.

Two alternate routes are available for this connection, as shown in Fig. 2. The first, by way of the Chicago River–Sanitary Canal, is a practical commercial route at this time, but craft navigating it must be able to pass under bridges having normally about 16 ft of vertical clearance and not more than 14 ft at high lake stages. This clearance is slightly less than is afforded on the New York State Barge Canal. The route follows the Chicago Sanitary and Ship Canal from Lockport to its junction with the West Fork of the South Branch of the Chicago River, near Damen Avenue, Chicago, a distance of 30.1 miles; and thence to Lake Michigan via the Chicago River, a distance of 6.1 miles. Although the Chicago River is a navigable waterway, available for use by masted vessels, and although the Sanitary Canal was built with the thought that it could be used by masted vessels, experience has demonstrated otherwise. The use of the Chicago River by masted vessels is rapidly becoming an economic and practical impossibility because of the time required for navigating the river, the delays at bridges, and the high towing charges. Because of its curvature, only the small and medium-sized lake vessels can now use it. The Sanitary Canal has never been used by masted vessels.

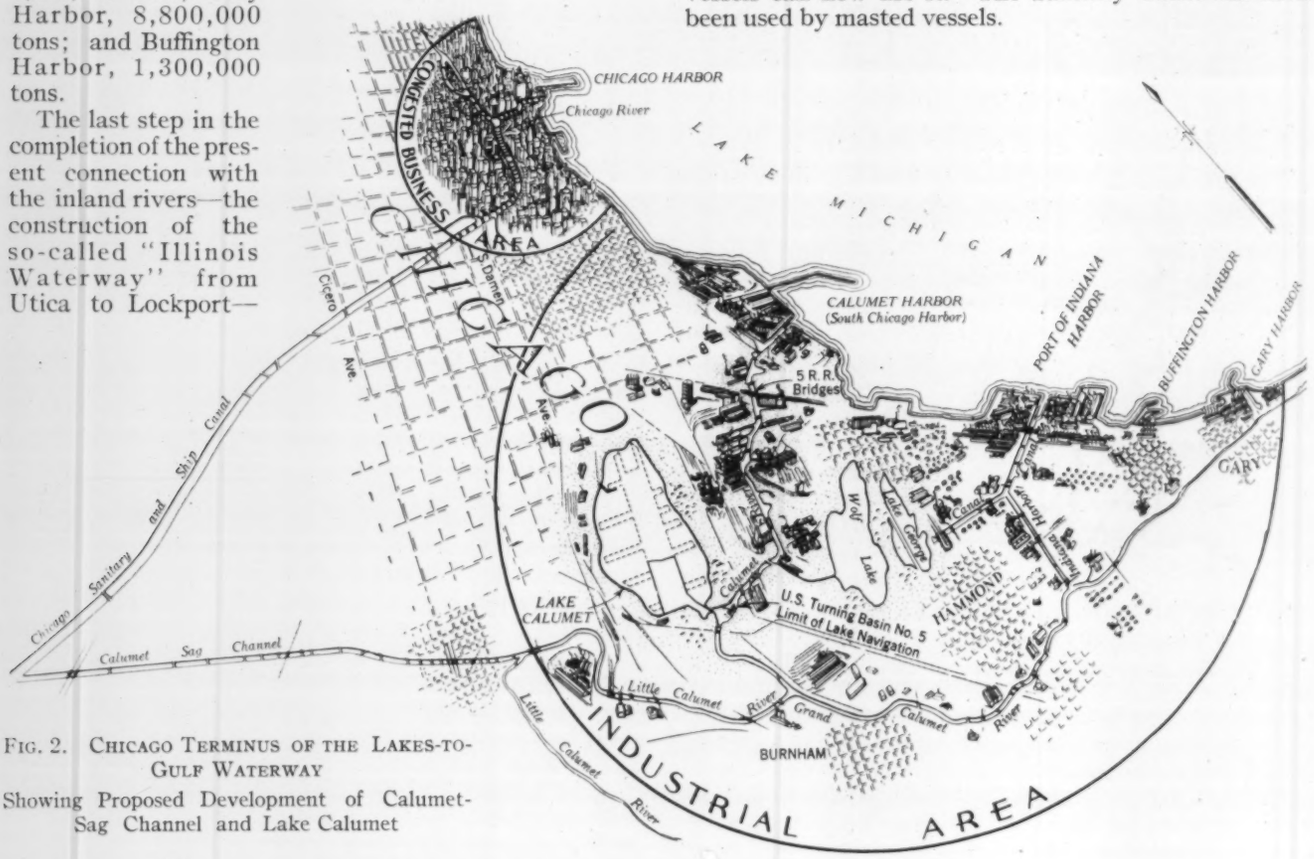


FIG. 2. CHICAGO TERMINUS OF THE LAKES-TO-GULF WATERWAY

Showing Proposed Development of Calumet-Sag Channel and Lake Calumet

The second route, usually designated as the "Calumet-Sag route," is not now practicable for commercial traffic. It is too narrow to allow moving craft to pass one another except at places provided for the purpose, and these are inadequate in length and spaced at 3-mile intervals. The route follows the Chicago Sanitary and Ship Canal northeasterly from Lockport 12.4 miles to Sag Junction; thence it continues for 16.2 miles along the Calumet-Sag drainage canal, which has a width of only 60 ft, to its junction with the Little Calumet River; and finally follows the Little Calumet and Calumet rivers to Calumet Harbor on Lake Michigan, a total distance of 42.4 miles. Bridges along this route offer a normal vertical clearance of 14 ft, which may be reduced by high lake levels to as little as 11 ft.

Any waterway problem in the area of greater Chicago involves complicated bridge problems. The city is situated on a level prairie only a few feet above lake level. The rivers passing through the city are comparatively narrow and can be readily bridged. As a result, 104 movable bridges and 66 fixed bridges have been constructed in 83 miles of navigable channel. The bridges across the Chicago River are movable, with very little clearance when closed; and during rush hours the competition between land and water traffic is rapidly causing strangulation of the latter. Satisfactory grade separation along the Chicago River, to allow through water traffic under fixed bridges, would involve a prohibitive expense for the alteration of bridge approaches and street grades. Although the bridges across the Sanitary Canal were designed and built to be movable, the operating machinery has never been installed. The Sanitary District recognizes its obligation to install machinery in these bridges but at the present time is without funds for the work.

Along the Calumet-Sag route the traffic problem is considerably less acute. Although there are 61 bridges between Lockport Lock and Lake Michigan, as compared with 54 on the Chicago River route, much more of the area traversed is open country; land traffic is less dense; and adequate bridge clearances can be more readily obtained.

From the point of view of the highway engineer, bridges should have such grades, elevations, and dimensions as will facilitate the movement of street traffic and will not impair or destroy the usefulness of adjacent property. The greater the clearance provided under such bridges, the higher their cost of construction and maintenance, and the steeper or longer their approaches. Every foot of length and inch of height increases the damage to adjacent property. The railway engineer must consider the same problems, and in addition he must estimate the damage to near-by railroad yards, to crossings with connecting railroads, and to other railroad facilities.

FACTORS AFFECTING BRIDGE CLEARANCES

The question of adequate clearance for river tows is determined primarily by the height to which the eye of the pilot must be elevated in order that he may safely guide his tow through restricted channels, into locks, through bridges, and past other tows. The problem thus resolves itself into a determination of the size of tow that will be necessary in order to secure economies sufficient to attract a large water tonnage. The channels and other facilities below Lockport are first-class in every respect. The locks, as has been mentioned, are 110 by 600 ft and will accommodate barges with a capacity of 12,000 tons of freight. A wet ditch above Lockport, with narrow channels, toy locks, and miniature bridges, will defeat the purpose of the entire Lakes-to-Gulf Waterway.

Covered box barges used on the Mississippi River and connecting waterways vary in width from 33 to 48 ft, in length from 126 to 300 ft, and in capacity from 500 to 3,000 tons. The vertical clearance required by these covered barges, when light and unballasted, varies from 16 ft to a maximum of 25 ft 4 in. It has been demonstrated that for Illinois River tows of proper size, especially as to length, the eye of the pilot should be 31 ft above the water surface for safe navigation. The vertical clearance of bridges must therefore be about 35 ft above the water surface at high-water stages. Such a clearance does not permit the movement of masted vessels; contractors' plant, such as high derrick boats; or river steamers in the passenger carrying trade. It is, however, adequate for economical commercial traffic by towboats suitable for service on the Illinois River, provided stacks and masts are hinged.

PRESENT TERMINUS OF THE LAKES-TO-GULF WATERWAY
Relation to Mouth of the Chicago River and "Loop" District

Bridges carrying a heavy land traffic, either rail or highway, over waterways carrying a heavy barge traffic, must be fixed at an elevation that will permit free movement of tows. Frequent bridge openings are intolerable, both to land and water traffic.

ADVANTAGES OF FIXED BRIDGES IN CHICAGO

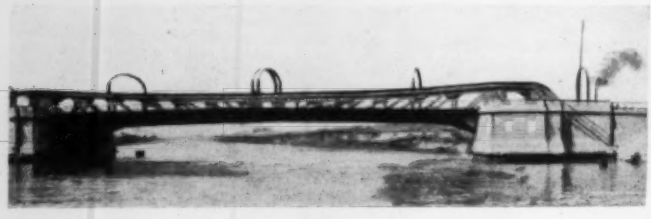
The City of Chicago has built most of its bridges over the Chicago River and its branches to a standard vertical clearance of $16^1/_2$ ft above the Chicago city datum, $13^1/_2$ ft above high water. It proposes to increase this to 21 ft above datum (18 ft above high water) by thinning the floors on new bridges as built. Fixing the bridges in the metropolitan area of Chicago would result in a saving to the city and Sanitary District of about $45,000,000 in the next 15 years.

From five to ten million tons of commerce per year may move between Chicago and the inland rivers when an adequate connection is made. The location of this adequate connection should be determined, not only by a solution of the problem of channels, with its related problem of bridge clearances, but also by the adequacy and location of terminal sites and areas.

An adequate general terminal, where lake and river commerce will meet, must be readily accessible to lake

vessels and river tows. It should provide facilities for transfer between barge or ship and wharf, and between barge and vessel; ample warehouse, stock pipe, and tank storage areas; trackage to warehouses, stock piles, and wharf side; storage and make-up yards for rail service; rail connections that ensure connection between terminal, trunk-line railroads, and switching-district industries with a minimum of switching charges; facilities for shipping in and out by truck; and service for vessels, including fuel oil, bunker coal, ship supplies, and tugboats.

If the economies incident to fixing the bridges over the Chicago River are to be realized by the City of Chicago, no terminal west of Michigan Avenue can serve as the junction point for lake vessels and river tows. Studies have also been made regarding the practicability and desirability of establishing a water terminal on the lake front at the Navy Pier, together with supplementary facilities near the pier or in Ogden Slip. The temporary use of the Tribune docks in the Chicago River has also been proposed. All these facilities are capable of being used for a comparatively small tonnage now, but the amount of possible expansion is not great.



BRIDGE OVER CHICAGO SANITARY CANAL AT CICERO AVENUE
Double-leaf Bascule Lift Span of Recent Type Not Equipped with Operating Machinery

It has been suggested that Brandon Road Pool be made the terminus of full-sized river tows. The movement of river barges from this break-up pool to destination by means of harbor-tug service will impose an additional cost on the movement of cargoes. In many cases this cost will entirely offset the economy of movement by water.

PROPOSED LAKE CALUMET TERMINAL DEVELOPMENT MEETS REQUIREMENTS

Most students of the problem of a terminal in the South Chicago area to serve the industries there agree on the desirability of developing Lake Calumet. It is a marshy lake, lying within the limits of the city proper, and draining into Calumet River at a point five miles from Lake Michigan. It is, roughly, 3 miles long, $1\frac{1}{2}$ miles wide, and from 1 to 10 ft deep, and is surrounded on all sides by important railroad lines and industries. The City of Chicago has been granted the ownership of the bed of the lake by an act of the state legislature and has settled the claims of all riparian owners except one or two. A plan for the development of the lake as an industrial and commercial harbor is shown in Fig. 2.

The development outlined for Lake Calumet meets the requirements of a general transfer harbor for package freight and bulk commodities between rail and water, or lake and barge. It assumes that the terminal will be open to the public on equal terms to all. The Illinois Section of the Lakes-to-Gulf Waterway will not be a success unless it carries an enormous tonnage of low-grade bulk commodities. Such a business is primarily suited to contract or private carriers. The terminal structures for this business are comparatively simple and should be provided and financed by the interests making use of them.

While the commerce on the Chicago River has dwindled, the bridge costs have mounted steadily to the point where they are a serious burden on the taxpayer. The present intolerable conflict between land traffic in the "Loop" district and water traffic on the Chicago River will be further aggravated if the river commerce derived from the Lakes-to-Gulf Waterway is introduced into the Chicago River. It would appear that the sound solution of these problems in Chicago proper is to convert the major part of the movable bridges to fixed bridges with vertical clearances sufficient to accommodate barges. Such a policy will involve the exclusion of lake vessels from the Chicago River and make necessary the provision of another main connection with the lake to provide a junction point for lake vessels and full-sized river tows.

ECONOMIC ADVANTAGES OF CALUMET-SAG ROUTE AS COMPARED WITH CHICAGO RIVER

This means the improvement of the Calumet-Sag route as the main connection of the Lakes-to-Gulf Waterway. It will cost $20,800,000 for navigation facilities and $18,900,000 for bridges, a total of $39,700,000. In addition it will entail operating costs for movable bridges of $25,000 a year.

If the Chicago River route is to remain the chief connection, all bridges between Cicero Avenue and the lake must be movable. Under a normal replacement program, the cost of changing them to movable bridges in the next 15 years, plus capitalized cost of operation, is $75,000,000. If the Chicago River route is to be only a secondary route for the local movement of barges, with fixed bridges having a vertical clearance of 21 ft, this 15-year replacement program will cost only $30,000,000. The saving thus effected is greater than the entire cost of the Calumet-Sag improvement.

There are other advantages besides this favorable cost factor. The Calumet area is a source of great potential commerce for the waterway, while the central metropolitan district of Chicago is of much less importance in this respect. To make the Chicago River route a secondary channel would expedite land traffic, since fixed highway bridges could be used over the Chicago River and also over that section of the Sanitary Canal where the crossings are most closely spaced. The Calumet-Sag route traverses a less congested area, where ample room for future expansion is available. Future industrial and commercial growth could be accomplished in an orderly and comparatively inexpensive manner. Lake Calumet offers an appropriate and most favorable site for an interchange terminal for lake and river commerce and is within a reasonable distance of Lake Michigan.

The accomplishment of this undertaking involves the cooperation of some eight governmental agencies and numerous private interests and individuals. It will take time. The initiative must come from the citizens of the municipalities involved.

Until the problems of distribution of costs can be worked out, and Congress has approved the project as a whole, the bridges over the Sanitary Canal should be made movable so that the Chicago River route—the only one now available—can be used by covered barges and river tows. In addition, some work should be done to make the Calumet-Sag channel usable to a limited extent.

Can the Costs of Government Be Reduced?

Discussions and Analyses of the Taxes Levied by Federal, State, and Local Administrations

AT the general technical session on June 27, 1933, at the Society's Annual Convention in Chicago, the Engineering-Economics and Finance Division took the responsibility of presenting an open-forum discussion on the subject of ways and means of reducing the costs of government. The authors of the principal discussions, each an expert in his field, were selected because they were not engineers, thus giving members the advantage of outside viewpoints. The object was to find some constructive ways in which engineers might be of assistance in the solution of this vexing problem.

In introducing the subject, Charles Keller, M. Am. Soc. C.E., Chairman of the Division, said:

"While money from taxes is the lifeblood of governments, too little emphasis is generally placed on the fact that these taxes must come from our citizens and that these citizens are to that extent less able to live and to do business and to consume.

"Some men in public life criticize business and business men for their methods or lack of methods, and they preach the need of a planned national economy. If planning and economy are desirable for business, why not also for government? Why should government do things that are not dictated by the rule of genuine public convenience and necessity? Can first-class harbors at Boston, New York, Philadelphia, and Baltimore, within a distance of, say, 400 miles, all of them serving substantially the same territory, be justified? Where is the profit to anyone in building elaborate post offices in small towns now adequately served in rented quarters? Does not the result give employment to a few for a short time at the expense of the owners of the property now rented?

"Why build an expensive all-American canal to reclaim more land in the Imperial Valley; why do the things contemplated in the Tennessee Valley; why the Columbia Basin project; when the country is now suffering from an overabundance of fertile land and the Government actually proposes to pay rent so that land may be taken out of production?

"What justification can there be for more power plants and additional transmission lines in regions already fully served? Do not these very things destroy the property of the citizen and his capacity to pay taxes? If the words "planned economy" mean anything practical, they must mean careful consideration and determination whether any and all proposals for spending the taxpayer's money are for really indispensable services, whether each proposal contemplates efficient and economical performance, and, most important of all, whether the taxpayer is able to pay the bill.

"What is needed is true economy in government, planned to serve those common needs of all citizens which alone government should supply. Superfluous or unjustifiable governmental agencies and activities must be eliminated and logical planning and economy introduced so that the consuming power of the taxpayer may be protected and preserved. Our problem is to determine how these things shall be done."

General Keller then presented Mr. Goodrich, Chairman of the Division's Program Committee, who stated the problem in its general terms. He was followed by Professor Bane, Dr. Gulick, and Mr. Rightor, who discussed the national, the state, and the local phases of the topic. Abstracts of these four presentations follow.

The Federal Tax Reduction Problem

By ERNEST P. GOODRICH

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IN the discussions of the taxation problem here presented, the word "taxes" is to be understood as practically synonymous with the phrase "costs of government." The question under consideration then becomes: "Can the costs of government be reduced?"

For 1930, the total tax payments to all units of government—national, state, and local—are estimated by the National Industries Conference Board at a little over ten billion dollars, roughly three billion to the Federal Government, two billion to the states, and five billion to local governments and agencies. Obviously, to each individual it is the total tax—Federal, state, county, municipal, school or other district—which is of moment. It matters little to him whether or not there is a shift of collection and expenditure from year to year so long as his total is bearable. In 1929 taxes were not felt to be excessive, but at present they are so considered. It has been estimated that all taxes were about 6 per cent of the income of the Nation's citizens in 1929. This year they are about 20 per cent.

Again, heavy taxes may be borne with equanimity if the taxpayers feel that they are receiving the value of their money in return. This applies equally to long-accepted governmental activities and to activities formerly conducted by private business and recently assumed by the government. Many rapidly growing communities have cheerfully carried heavy taxes because they felt that later years would pay dividends through the enlargement of their population. The Cincinnati-Southern Railroad, which was so financed by the City of Cincinnati, now makes large annual returns to reduce that city's taxes. Otherwise these taxes would have to be levied elsewhere

or else the city's operations would have to be curtailed. The normal per capita tax in high-type residential communities such as Brookline, Mass., or Winnetka, Ill., would be unbearable in manufacturing towns of equal size. The tax burden is thus seen to be a matter of time, place, and circumstance.

ACTIVITIES OF FEDERAL GOVERNMENT INCREASE

Consider first Federal costs—also Federal taxes, over one-half of which are included in the income levies. The first question that arises is: Can Federal taxes be reduced permanently? The answer is: Probably not. A trend seems clearly evident toward less freedom for the exercise of individualism, the excesses of which have been blamed by many as the cause of the recent economic difficulties. More and more, society is taking over, for operation or control, fields that were once accepted as belonging in the sphere of individual or private initiative, such as highways, water supply, housing, public utilities, and banking. This trend seems certain to continue, in spite of strenuous opposition, and it will certainly increase governmental costs.

Engineers should become members of taxpayers' associations, business men's clubs, and chambers of commerce and enter their discussions to educate the membership along proper economic and engineering lines. Engineers must therefore be able to speak in public and they must do so. They must study and apply economics.

—E. P. GOODRICH

The fact that government is taking over more and more activities is shown by the following significant facts: in 1902 irrigation, reclamation, and conservation were started; in 1903 construction of the Panama Canal was begun and the Departments of Commerce and Labor were created; in 1906 the Pure Food and Hepburn Railroad bills were passed; in 1909 the Income Tax law was passed; in 1912 the last two states were admitted to the Union; in 1913 the Budget Commission was created and parcel post was initiated; in 1914 the Federal Reserve System and the Trade Commission were created; in 1919 the Prohibition Amendment was put into effect; and in 1931 Federal aid for highways was started. Some of these were new activities, while others were transfers to the central government of state and local functions. All of them added to the number of employees on the Federal pay roll.

From 1800 to 1860 Federal income remained fairly uniform at about $2 per capita. From 1865 to 1895 it gradually fell from about $10 to $5 per capita. From 1900 to the World War, the rate was around $7, with a general trend downward. Since 1925, the rate has been in the vicinity of $25 per capita, again with a sagging tendency. On the other hand, during the past 25 years, except for the War period, the number of Federal employees has been almost proportional to the total population of the continental United States. The problem, then, seems to be to determine what new fields are to be entered by the central government and how rapidly.

TAXES ORIGINALLY FOR REVENUE, NOW FOR CONTROL

These comments raise the whole question of the theory of taxation and its incidence. In this country taxation was originally for revenue only, and many strange sources were tapped, resulting in such levies as the window tax of Colonial times. Later, taxation was invoked for purposes of control—the protective tariff, railroad rate regulation, the old excessive liquor taxes, and the excess profits tax. A tendency now seems evident toward an increasing use of taxes as a control mechanism. The constitutionality of the graded income tax would seem to set a precedent for many other graded taxes with control as an objective, and new applications are to be expected if past tendencies are accepted as a criterion.

Because of the trend toward the entrance of government into business, toward centralization, and toward the use of taxation for purposes of control, it is probable that Federal costs—and taxes—will increase. If the total costs of government are to be reduced, it then behooves the citizens to look for relief to the state, county, municipal, and district authorities. This does not mean, however, that no effort should be exerted to secure relief from Congress.

If costs can be prevented from rising while population increases, then the per capita cost will fall. If the cost of the Federal Government can be kept from increasing during the next 50 years, then the average tax burden will be reduced by 20 per cent. This is a slow process and has the special drawback that it does not remedy present unbalanced tax incidence.

The relative weight of Federal taxes can be reduced: by pegging Government costs while increasing personal income; by limiting Government costs to a constant per cent of the total national income; by reducing living costs in relation to a given income and the tax ratio; by equalizing the tax incidence more nearly according to the ability to pay; and by doing all these things, or others, through a planned economy program administered by a responsible technical, non-political, continuous representation.

TAXATION AXIOMS

As to state, county, municipal, and district taxes, the taxpayers, and engineers in particular, should see: (1) that activities are limited to available income, budgets being balanced for credit reasons if for no other; (2) that the administration is efficient, that there are no unnecessary activities and no waste, and that the various activities are carried on in proportion to their actual value, by setting up measures of efficiency rating in every field; (3) that both operating costs and public improvement expenditures are budgeted for several years ahead; and (4) that as Federal taxes increase, others decrease.

It will be claimed that efforts along these lines have been fruitless in the past and that something new must be provided—something spectacular. Social psychology seems to have changed to some extent of late. Measures put into effect today, if they are to be satisfying and efficient, must be different from the old ones. There is an almost world-wide iconoclastic unrest. The following suggestions are submitted in the light of these thoughts:

1. Debts should be made payable in dollars of the same value as those borrowed. This will lighten the debtor's burden during periods of deflation and guarantee the creditors' income during inflation.
2. Creditors should be required to maintain a real or a theoretical sinking fund, the collateral being jointly owned. This will lighten debtors' burdens.
3. All persons without income should be placed in semi-military collectives. This will reduce charity contributions of all classes without increasing government costs proportionately.
4. All governmental units should be permitted to borrow enough to cover one year's obligations and thereafter be required to expend no more for all objects during any succeeding year than has actually been collected

during the preceding year. This will prevent state and municipal extravagance.

5. An economic planning bureau should be created. This should increase and equalize incomes.

6. A social planning agency should be established to increase and balance incomes more equitably.

7. An excess production tax should be created to limit over-production. This should prevent economic depressions.

8. A Federal foreign trade corporation should be created to control all exports and imports. This should decrease Federal taxation.

9. Every group that secures Federal fiscal aid should be operated without profit until the loan is repaid. This should reduce interest rates and at the same time lower the cost of living.

There is no single cure-all; the social body is too complicated in its functioning. Fortunately we have lately become accustomed to large and bitter doses of medicine. It is to be hoped that this fact will result in even more comprehensive treatment. The "brain trust" has made an excellent start. It is hoped that engineers will develop something of even greater value to society, for both the immediate and the distant future.

Reducing State Taxes Impracticable

By FRANK BANE

DIRECTOR, AMERICAN PUBLIC WELFARE ASSOCIATION, CHICAGO, ILL.

EACH level of government—Federal, state and local—probably considers that any necessary reductions in taxes should be made in the levels other than its own. This year 43 state legislatures have been confronted with the problem of tax reduction. Stimulated to some extent by numerous taxpayers' organizations, they assembled in January and immediately attacked the problem of reducing taxes. Everyone agreed, in general, that taxes should be lowered; everyone agreed, in general, that expenditures should be reduced. And there the agreement ended. When it came down to the question of just how the expenditures should be reduced, difficulties arose. It immediately became apparent that more than 82 per cent of the total cost of state government in this country goes for four general activities: first, education; second, welfare; third, highways; and fourth, public health. It was obvious that if any material reductions were to be made, the costs of these four services must by some means be lowered.

APPROXIMATE DIVISION OF THE STATE TAX DOLLAR

Education	$0.40
Public welfare	0.21
Highways	0.18
Public health	0.03
Conservation and development	0.05
Regulatory commissions	0.05
Legislative, executive, and judicial bodies	0.08
Total	$1.00

Within the last two decades there have been enormous increases in the cost to states of education, so that today 40 per cent of the total cost of state governments goes for this purpose. These increases have been brought about, first, by an increase in teachers' salaries; second, by an increase in the number of children that must be taught, because of statutes making education compulsory; third, by enlargement of curriculums to include some of the so-called frills of vocational training, such as home economics, music, recreational activities, and libraries; and fourth, by the construction of many larger and better equipped buildings.

SHOULD THE COST OF EDUCATION BE REDUCED?

If the cost of education is to be decreased, something must be done about the four things that have caused it to rise. First, it is possible to reduce teachers' salaries. It is apparent that such a reduction, maintained over a period of years, will reduce the professional standards of those who teach our children. In some communities where a reduction was particularly necessary, another way of handling the matter was found; teachers' salaries were not paid at all. That method of course saves money much more rapidly than even reductions would do.

Second, the cost of education could be reduced in another way, by repudiating the oft-stated American maxim that "every child in this country shall be entitled to an education at public expense." For our present system can be substituted one that will educate only certain select children. That will save a great deal of money. In the third place, the curriculum can be contracted by effecting a return to the "three r's" and the "ways of our fathers." That will also save money. Then, in the fourth place, a little money can be saved by ceasing to put up more and larger buildings.

Certainly, in this particular as in many others, government is a commodity, and to a large extent the taxpayer gets in quality and quantity what he pays for. Taxes can be reduced, then, by reducing educational costs if the citizens are willing to sacrifice the quality and quantity of the education afforded their children.

The second most expensive activity carried on by the state falls under the head of what is commonly called public welfare and is denominated generally by the census bureau as charities, corrections, and protection. Here about 21 per cent of the taxpayer's dollar is spent. Before the depression, the largest single item in the welfare activities of state governments was the care of the insane, epileptic, and feeble minded. In this country millions of dollars were and are being spent to provide institutional and hospital care for those who are mentally ill or mentally defective. These institutions are notoriously crowded. Also, throughout the country they are notoriously poorly staffed.

One of the easiest ways to reduce the cost of the care of the insane is to stop taking more people into hospitals. Another would be to reduce the maintenance cost of those who are already there. This cost, of which the largest single item is food and in hospitals of that kind raw food,

probably runs from 18 to 25 cents per day. If it is decided that the state is not to take care of any more persons who are insane, epileptic, or feeble minded, the net result will not be a saving to the taxpayer because the cost that is now borne by the state will have to be borne by the local community, where these persons will collect in almshouses, jails, and other institutions.

The second largest item of expenditure under welfare is the maintenance and operation of prisons and correctional institutions. Almost everyone in the United States, thinking of crime collectively, has an idea that what he wants to do is to put teeth in the statutes and enforce the law. However, he has a decided objection to paying the cost of caring for so many people in prisons. It costs almost as much to take care of one convict in a prison as it does to supply relief to a family of five on the outside.

Many efforts have been made from time to time to reduce this expense. Welfare officials and prison officials have devised many schemes to put convicts to work, but as fast as schemes are devised, some legislatures decide that they shall not be put into effect because if a convict works in a particular industry he will compete with somebody on the outside.

The third item in welfare costs, the one that is being discussed at this time more than any other, and the one that at present is costing more, probably, than any other single item of government, is public relief. It has been estimated that last year this country spent approximately one billion dollars for such relief, and that on May 1 approximately 18,000,000 people were getting aid from either public or semi-public organizations and agencies.

Only one thing is required to cut down enormously the amounts expended for relief—find jobs. That is all. But the modus operandi by which this can be accomplished is probably not so simple. Certain it is that if this country adheres to the general policy that people shall not starve and freeze, enormous amounts of money for public relief must be spent until industry can be rejuvenated in such a fashion as to absorb a large part of the present excess of labor.

Expenditures for highways constitute about 18 per cent of the total cost of state governments. Suppose it is agreed to reduce highway construction by approximately 50 per cent as an economy measure; then in all probability welfare expenditures would have to be increased some 15 per cent to take care of the people put out of work. In so far as highways are concerned, it is simply a question of how many miles of road the taxpayer desires to buy and whether there is money to pay for them.

Expenditures for public health are only approximately 3 per cent of the gross cost of state governments and probably yield larger returns to the general public than any other outlays made. Certainly any material reduction in this direction would seem to be saving at the tap and losing enormously at the bung. The best job that has been done in the government field in the last two decades perhaps has been done by public health authorities.

Of the remaining items that go to make up the cost of state government, that of conservation and development amounts to approximately 5 per cent, and various regulatory activities, public service commissions, industrial commissions, and labor departments account for 5 or 6 per cent, leaving altogether about 8 or 10 per cent for governmental functions in general, in the legislative, executive, and judicial branches.

Material reductions of 20, 25, or in some places 50 per cent have been effected in state expenditures, but they have meant, inevitably, very material curtailment of those collective services that have been built up over a period of 25 or 30 years. These services mean a great deal to the people, and can be purchased more cheaply through government than in any other way. The damage done to the general public by material reductions in these essential activities has been perhaps far greater than the benefits that have resulted from the savings effected.

Reorganization of the State

By LUTHER GULICK

DIRECTOR OF THE INSTITUTE OF PUBLIC ADMINISTRATION, NEW YORK, N.Y.

THERE are two kinds of economy, fundamental and secondary. Efficiency engineers, students of management, and professional people as a whole have wasted a tremendous amount of energy by not distinguishing between the two. For example, examine the development of automobile accessories. Think of the anti-rattlers and the devices for preventing steering wheels from jack-knifing. Most of the time put on these jimcracks was thrown away. What was needed was not a superficial palliative, but a fundamental change in design to make such things unnecessary.

In the field of government, these two types of economy are also observable, termed constitutional economy and procedural economy. Most discussion regarding the reduction of taxes and the elimination of expenditures is directed toward procedural economy. This has its place, but it is distinctly of secondary importance. Many of these procedural problems will automatically disappear when the underlying constitutional changes are made. First of all then, consider the problems of constitutional economy in the American state.

What are the functions performed by these 48 states of the American Union, the 48 commonwealths that comprise our country? They pass laws and enforce them to maintain order and preserve personal and property rights. They protect minorities and prescribe election machinery. They also render important community service through the development of education, highways, state parks, and various state institutions. They set up local governments and regulate their financial and other powers and procedures. They regulate banks, insurance companies, transportation and other utilities, and create corporations. They conserve natural resources, regulate labor, fix hours and conditions of work, and establish workman's compensation. They determine the tax system, both for the state and for the local units of government. Under the American Federal system, there are 48 sovereign and independent republican states, each in complete control, with certain restrictions, of its own governmental affairs except for foreign relations, the currency, the liquor business, and interstate commerce.

This brings us to the fundamental, the constitutional question of economy in state government. Is the state

the appropriate instrumentality for the discharge of these sovereign functions? The answer is not a matter of conjecture or delicate appraisal. It is a matter of brutal record. The American state is finished. I do not predict that the states will go, but affirm that they have gone.

And why have they gone? Because they were unable to deal even inefficiently with the imperative, the life and death tasks of the new national economy. Where were the states when the banks went under? Powerless Maryland, hysterical Michigan, safety-first New York! Where were the states when all the railroads were on the verge of passing into the hands of the bondholders and suspending operation? Where were the states in the regulation of power and the control of utilities? Where are the states now in regulating insurance companies, with their fake balance sheets and high salaries? Where were the states in controlling blue-sky securities? Where were the states in preventing destructive business competition and in protecting labor and the public? Where were the states in the development of security through social insurance? In none of these fields effecting economic life was it possible for any state to do anything decisive without driving business out of its jurisdiction into areas where there was no regulation and no control.

A closer relationship between the engineer and the layman is needed. That means a better analysis by the engineer of the problems of engineering economics that are involved in such things as highways, bridges, railways, and ports. In the last analysis the layman must decide as to the wisdom of going forward in these various directions, but he must have the advice of the engineer in arriving at a decision. If engineers, especially those in public service, will give the layman the whole picture, with all its implications, he will probably be able to reach a reasonable solution.

—LUTHER GULICK

The same kind of sectional self-interest made it impossible for any state to go forward boldly with public improvement programs to offset industrial contraction. And finally, where have the states landed in the development of their tax systems? The inheritance taxes were a hopeless muddle of conflicting and duplicate taxation until the Federal Government stepped in with its credit provision. Where are the states headed now with their taxation of personal and corporate incomes, of manufacturers, of retailers, of gasoline, of motor vehicles, of tobacco? This whole system of unfair duplicate taxation, with unnecessary jurisdictional conflicts and wasteful duplicate administration, is on the road to collapse.

POLITICAL AND ECONOMIC BOUNDARIES

These problems are mostly national in scope. It is extremely wasteful, and in most cases impossible, to solve them state by state. There are two reasons for this fundamental impossibility. First, a problem cannot be solved when only a small fragment of it is available, because of the sheer lack of knowledge and power. Second, the solution of a problem is impossible when it is split up among competing entities, thereby introducing conflicting considerations of self-interest. No state can afford to go far in labor regulation, in business stabilization, or in the use of credit or taxation as a social tool when it is a part of an economic system including other states that do not take such steps. Under the traditional system of government represented by the 48 states, by hundreds of cities, and by thousands of counties, it has been considered wise fiscal policy for each individual government to retrench, to stop all road work and other public works, although this policy has been disastrous for the country as a whole, including the individual communities themselves.

Nothing effective can be done in the regulation or stabilization of economic affairs unless the area of planning and control has the same boundaries as the economic structure. For many problems that area is now the Nation. There is nothing mysterious about the new legislation in Washington. All these laws, though they may contain impractical and absurd provisions, are an expression of an irresistible force in American life rising from the economic integration of the 48 states. Though we have not changed the Federal Constitution or amended the state constitutions, these new economic measures signalize the end of the state as it has been known in the past. They are a recognition of the fact that the states can no longer deal successfully with broad economic questions, but that these must be transferred wholesale to the National Government or to some regional authority set up by it.

REQUIRED TRANSFER OF FUNCTIONS

If the tasks of economic control and stabilization are beyond the competence and power of the states, is it not clear that the time, effort, and money which the states are spending in these tasks are largely thrown away? It is therefore my first suggestion that the states abandon these activities and transfer them to the Federal Government, directly and honestly, through amendment of the Federal Constitution. Such amendment would not be revolutionary. The revolution has already taken place. The states have failed; the Federal Government has assumed responsibility for the work. The Constitution and the law must be made to conform to avoid needless complications, judicial squirmings, and great waste of time and money. Without clean-cut constitutional revisions, the states will continue to maintain their futile duplicating organizations at great expense.

All essential powers affecting economic planning and control must be taken from the states and given to the Nation. These would seem to include all control over banking, insurance, credit, transportation and communication, social insurance, creation of corporations, regulation of utilities, major highways, automobile licensing, labor, production, prices and profits, and finally, taxes, with the exception of those on real estate, which after all is not fluid. If these fields were added to the ones in which the National Government already has authority—the currency, commerce, and international relations—it would be equipped to do its work without constitutional hindrance or subterfuge.

THE NEW STATE

What would the states then become? They would become organs of local government. They would abandon their wasteful and bungling endeavors and pretense of competency in the field of national economics and settle down to perform honestly and successfully their allotted tasks in creating and maintaining the organs of local government and service.

A study of budgeting indicates that the abandonment of that function in the average state would immediately remove some 10 per cent from the annual budget. For the Nation as a whole, the total saving would amount to perhaps $130,000,000. Although this is not a large amount, it is too much to throw away. But the real economy goes far beyond this, and arises

from the elimination of friction and frustration, and from the fundamental reorientation of the state government. If the things which it cannot do are removed from its jurisdiction and it is left only the things that it can do, will not the result be clearer thinking, better planning, and that development of morale which comes with successful achievement?

The next task will be the redistribution of all the functions of local government between the various local agencies, and the reorganization of the new state for business and planning. This will inevitably lead to a host of procedural reforms in organization, finance, and methods. It is along these lines that we may hope to achieve actual, extensive economies in state government.

Curtailment of Local Taxes Inadvisable

By C. E. RIGHTOR

FORMERLY COMPTROLLER OF THE CITY OF DETROIT, MICH.

OF a total population of 122,000,000 in the Nation, 40 per cent live in 310 cities of over 30,000. Those cities are serving their citizens continuously and intimately in all the social and economic activities of their daily lives.

Two years ago, Dr. Upson, Director of the Detroit Bureau of Governmental Research, made an analysis of the activities conducted by the City of Detroit. He found that the original 23 activities of 1823 had grown to 170 by 1910. Between 1910 and 1920, as many as 81 new activities were added, and between 1920 and 1929 there were 55 others, so that there is now a total of 306 specific activities conducted on behalf of the citizens of Detroit by the municipal government, including the work of the board of education and the library commission. These functions have all been added at the request of the voters and taxpayers.

One of the reasons for the tremendous increase in the bonded debt of American cities during the past decade, and consequently for the rise in the cost of government, is the ease with which city councils and urban voters can authorize improvement projects to be paid for by bonds "sometime in the future." Under a "pay-as-you-go" plan, the acquisition of public improvements is made judiciously and conservatively, the annual debt burden is lighter, and the debt condition of the municipality is therefore stronger. This fact has been emphasized during the present period of economic depression. While tax delinquency has been widespread, it has not been possible to reduce interest and amortization charges to correspond with the amount of taxes collected.

—C. E. RIGHTOR

Since 1929, however, cities have effected very substantial reductions in the cost of their governments. In Detroit, the less essential activities have been curtailed and the main ones have been continued on a reduced scale.

SERVICES RENDERED BY CITIES NECESSARY

Not considering debt service, the departments of police, education, health, and fire, require on the average 70 per cent of the municipal budget, the remainder being for street maintenance, building inspection, various other inspection services, park maintenance, recreational activities, and the conduct of the general offices.

Cities have reduced their expenses by combining and curtailing departments, by reducing salaries, and by limiting purchases of supplies and materials. But they have carried this policy of economy to an extreme, and the pendulum is now about to swing the other way. Citizens can afford to pay the cost of the local government and they should pay it. Stringent laws regarding the payment of taxes are needed so that the growing problem of tax delinquency can be met. Tax delinquency has led to numerous difficulties in many cities, particularly in the matter of debt service. This is one of the fixed charges that must be met whether there is tax delinquency or not. Some cities have actually defaulted, part of them because of inability to collect taxes and others because of such factors as the bank moratorium.

If a city is certain that all the items in its budget should be there and that the amount set opposite each is the minimum that should be expended, based on the value of the service and on comparative data for prior periods, then the total of all the items must be financed. It becomes a secondary matter to determine whether the financing is to be from general taxes on property or from some other source. Of course it may happen that the tax burden on real and personal property is unduly heavy, in which case consideration should be given to revision and modernization of the tax assessment system.

If the individual's taxes are to be reduced materially however, it is not the municipality that should bear the brunt of the reduction. It is my opinion, based on considerable study, that the five billion dollars spent by municipalities—out of the total of ten billions expended by all government agencies in the United States, as reported by the National Industrial Conference Board—cannot be substantially reduced.

The engineering profession can take a definite place in the solution of the city's taxation problems. Engineers could afford to analyze the municipal budget carefully every year, for it is the keystone of the cost of local government. Such an analysis would cover not only the current budget but also the public improvement budget for capital outlay over a term of years. It would include the preparation of a long-term financial program, which the municipality might sorely need. This work would be accomplished through cooperation with groups of responsible citizens, representing the taxpaying public. These groups would help the public officials to decide what the municipality should undertake, how much the program should cost, and how it should be financed.

Engineers could well afford to establish standards of public service by which to measure the value and the need of the activities being performed, including compensation of personnel. They could help "sell" the government to the people—present the facts to the taxpayers—because it is essential, particularly today, that the citizen should have a basic knowledge of such matters. Then there is the specific problem of setting up and administering an honest and scientific assessment system. This is distinctly an engineering problem.

Century of Progress in Construction

Engineers and Others Develop Many Phases of a Broad Subject

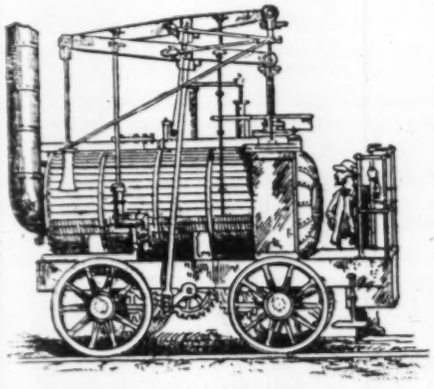
IN keeping with the spirit of the great exhibition now being held in Chicago, depicting the progress that has been made in the arts and sciences during the past century, the Construction Division of the Society arranged a symposium on the subject of improvements in construction during this period, for presentation on June 29, 1933, at the Annual Convention of the Society in Chicago. That colossal improvements have taken place in every phase of construction is clearly shown. Stronger materials have increased the span of bridges and the height of buildings. Motive power unknown 100 years ago has been developed for transportation on land and sea. Each of the following articles is an abstract of the longer treatment presented at the Convention. Together they form a vivid picture of the engineers' part in building larger and more useful structures at lower cost, and in removing forever the back-breaking drudgery that was required for all types of construction only a few generations ago.

Industrial and Engineering Achievements

By A. P. M. FLEMING

DIRECTOR OF RESEARCH AND EDUCATION

METROPOLITAN VICKERS ELECTRICAL COMPANY, MANCHESTER, ENGLAND



"PUFFING BILLY," BUILT IN 1813

IT would be impossible today to maintain the teeming populations of the world at the present standard of living if the transformation of Nature's resources into finished products depended solely on manual effort. The power necessary for this purpose has been made available by engineering achievement. Further, it would be impossible to distribute commodities without the facilities which that power has provided. In the development and application of this great asset, science has been the creative factor.

A brief survey of the world's industrial position in 1833 will serve as the base line from which some measure of the progress of the past century can be made. The principal industrial countries then were Great Britain, France, the United States, and Germany. In England and the United States most of the internal traffic was conducted by waterways, although the subject of road-making was beginning to attract attention.

There was no electric power and there were no means of communication other than direct contact or visible signal. Railroads were in their infancy, and iron ships were rare and considered so experimental that Lloyd's gave them a first-class rating for limited periods only. The application of steam power, except for railroads, mines, and textile mills, was proceeding but slowly. It is interesting to note that at the Royal Arsenal in Woolwich, cannon were still being bored in a mill driven by four horses.

As compared with today, standards of living everywhere were relatively low. In Great Britain particularly, the concentration of workers in towns without adequate provisions for housing, water supply, and sanitation led to much squalor and ill health.

AN AGE OF STEAM POWER

In a series of lectures delivered in Danzig in 1922, Professor Arrhenius estimated the total power resources of the world and specified 12 latent sources. There are now no unused sources for power that are likely to be developed in the near future, excepting the tides and solar emissions, although hopes of obtaining energy from the disruption of the atom are cherished.

The past century is justly regarded as an age of steam power. It commenced with all the more important features of the modern reciprocating engine suggested or in use; it saw the rise of this type of engine to its full development, as exemplified by the mighty quadruple-expansion engines of fast liners; and in its last quarter it has seen this type displaced by the steam turbine. The reciprocating engine is still supreme in one field, in which perhaps its greatest utility has been shown, namely, that of railway locomotion. Its decline in other fields is due only in part to the advent of the steam turbine, since the internal combustion engine, in horsepower and range of utility, today easily holds the foremost position.

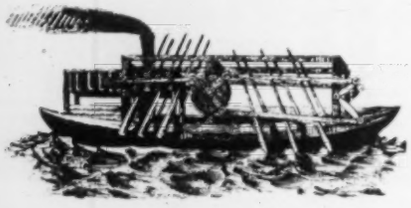
Application of the turbine to marine propulsion was made by Parsons in 1897, when the *Turbinia*, a 100-ton boat, was fitted with turbines of 2,100 hp, driving three propeller shafts. Ten years later battle cruisers were equipped with turbines of 41,000 hp, and the Cunard liners, *Lusitania* and *Mauretania* were provided with turbines developing 70,000 hp on four shafts. Electrical transmission in place of gearing has been employed for some of the largest vessels in the U.S. Navy and for certain liners. From the fact that some modern vessels are equipped with electric propulsion and others under construction are designed for mechanical gearing, it would appear that the respective fields of the two methods are still undefined.

The idea of a binary-fluid turbine has already been brought to a practical stage in the mercury-vapor turbine developed by Emmett of the General Electric Company. The performance of the power station now nearing completion at Schenectady, N.Y., comprising two

mercury-vapor turbine sets, each of 20,000-kw capacity, will be watched with interest.

INTERNAL COMBUSTION ENGINE INVENTED

As early as 1680 Huygens made a gunpowder engine employing a cylinder and a piston, in which a charge was fired when the piston was at the outer end of its stroke and a partial vacuum was produced below the piston as the hot gas cooled. In 1820 a suggestion was made to drive an engine by an explosive mixture of hydrogen and air. At the commencement of the century, Barnet proposed to use the compression of the charge as the motive force, a practice since universally employed. An outstanding development in the internal combustion engine was that of the Otto four-stroke cycle in 1876, which for gas and vapor engines has had no serious competitor since.



FULTON'S FIRST STEAMBOAT

A Forerunner of the Clermont, a Side-Wheeler, Which Made Its First Trip on the Hudson, from New York to Albany, in 1907

About 1895 Diesel developed the heavy oil-burning engine and surprised the engineering world by the unprecedented indicated efficiency he attained. The Diesel engine is the most universal prime mover developed during the century. In addition to its important application to marine propulsion and electric generation, it has been employed on airships, is used exclusively for submarines, is being tried out for airplanes, promises to compete seriously with the gasoline engine for heavy road vehicles, and has successfully operated certain kinds of railway traction cars. The great range in size and utility of the Diesel engine may be illustrated by the fact that in 1932 an engine of 22,500 bhp was constructed for electric generation.

What the future of the heavy oil engine may be it is difficult to forecast. But it is significant to note that since 1927 the total new marine tonnage of the world employing Diesel engines has substantially exceeded the corresponding tonnage driven by steam.

WATER—AN ANCIENT SOURCE OF POWER

Probably the oldest known form of prime mover is water. It is possible that the wonderful prime movers developed during this century, which are dependent for their motive power on coal and oil, may with the exhaustion of the latter be survived by the water turbine employing the energy of the natural waterfall. The modern water turbine is capable of meeting all probable needs as regards size of unit and operating head. In the last third of the century turbines have increased in size from 5,000 hp in the original Niagara Falls plant to 90,000 hp in the Dnieprostroy plant; and units of 100,000 hp are projected. The limitations at the moment appear to be in the manufacture of the forgings required for the larger sizes of shaft and in the transportation of the huge impellers.

Reverting to the possibility that the water turbine may be the prime mover of the future, it is interesting to note from the latest surveys of potential water power in the world that a large part, or 43 per cent, is centered in Africa, notably in the Congo. With the development of long-distance transmission and the husbanding and rationing of the world's power resources, what is at present the most undeveloped part of the world may become of the greatest importance in the future.

The first practical direct-current generator took the form of a cylindrical iron armature whose surface was over-wound longitudinally with insulated wire connected to a commutator, the whole being rotated on a shaft between the poles of a permanent magnet. The earlier developments in direct-current design were largely the result of guesswork; it was not until about 1886 that Hopkinson showed how to design dynamo-electric machines on a scientific basis. In the meantime such machines were reaching a commercial stage. In 1881 Edison exhibited a bipolar direct-current generator at the Paris Exhibiton, and in 1882 he installed a 100-hp "jumbo" machine in Pearl Street, New York. Machines of that day had to be tried out to see at what speed they should be run to give the right voltage, and tested for the number of lamps they would light without overheating.

Alternating current was not considered for other than local electric lighting until the serious development of the transformer took place. It was well known that the transmission of electrical power could be effected more economically the higher the voltage employed, since the size of the conductor depended on the volume of current to be dealt with.

The Columbia Exhibition at Chicago in 1893 was lit from alternating-current, two-phase machines. Within a third of a century the size of hydro-electric generators has increased from 5,000 hp in the case of the original Niagara generators to 90,000 hp for those recently installed at Dnieprostroy.

POWER TRANSMISSION AND DISTRIBUTION

The enormous demand for electrical power has led to an investigation of all economical sources of energy and to a search for the economic balance between a source placed near the center of demand and one at a distance from it but situated where coal or water power would be readily available. The modern trend has been towards transmission over longer distances at correspondingly higher voltages. There are now in operation numerous transmission systems of 220,000 v and some projected for 380,000 v.

A possible rival to the transmission of electrical power by alternating current is the method introduced by Thury a third of a century ago. He employed a number of direct-current generators in series and obtained a high transmitting voltage. The possibility of direct-current transmission at high voltages has been revived in recent years for very long distances, 500 miles and upwards. Much research is being conducted on this problem in different parts of the world.

The evolution of transformers during the century has undergone enormous changes. The early Gaulard and Gibbs transformers of 5 kw were considered of mammoth size. In 1900, a 2,000-kw unit was the largest in the world. Today units of 100,000 kw have been constructed, and there is no apparent limit to the output for which a single unit could be built.

A rough indication of the advancement during the century in the use of power for transportation is the time taken for a person to cross the Atlantic. Exactly 100 years ago the first entirely steam-driven ship to make the trip, the *Royal William*, crossed from west to east in 25 days. Today the *Bremen* makes the crossing in about 100 hr, while Miss Earhart crossed by air in 13 hr 30 min.

Next to transport, communication has been the most

important factor in the development of commercial and social life. Its history presents one of the romances of the century. In earlier times communication could only be carried on by messenger or between fixed points by semaphore or heliograph. The advance has been essentially by electrical means. As early as 1746 Watson transmitted electric signals through 10,000 ft of wire, using an earth return. In 1833 Morse developed a means of recording signals on a paper tape by the operation of an electro-magnetic pencil and in 1838 introduced the Morse code system of signaling by a single needle that could be read by eye or ear.

The next development of importance was the invention of the telephone by Bell in 1876. As a receiver his principle is still in use, but various other forms of transmitter have been developed since, notably Edison's carbon transmitter. In 1901 Marconi succeeded in transmitting across the Atlantic in Morse code the letter "S," and from that time on wireless telegraphy developed rapidly. The loss of the *Titanic* in 1910 gave a great impetus to the perfection and use of wireless signaling for marine purposes.

WIRELESS AND TELEVISION

A further phase of communication is that relating to the transmission of pictures, both with and without wires. This has now reached a stage of considerable development, as will be appreciated from the examples seen in the daily press. As a result of the perfection of wireless has come the modern institution of broadcasting, which took practical form in the United States in 1921. Its remarkable extension throughout the world is one of the most amazing developments of the century. The future holds the possibilities of television, which under special conditions has already been brought to a fair degree of perfection, although it is still in an incomplete stage as far as its general application is concerned.

The great modern civil engineering undertakings—the building of dams, harbors, and bridges, and the excavation of tunnels—have been facilitated enormously by the use of steam or electrical power. It is probable that many of these works could not have been undertaken economically without such assistance. In reviewing the use of power throughout the century it should be borne in mind that in 1833 the total amount of power available was probably less than that represented by a single one of the largest units in the Chicago Commonwealth Power Plant. It is estimated that the horsepower generated today is in the neighborhood of a hundred million kilowatts and the total investment in electrical power alone throughout the world is about two thousand million dollars. A conservative estimate of the horsepower installed in nine countries for which there are reliable statistics is 148,000,000, and this represents only a fraction of what might be usefully employed throughout the world.

THE PART PLAYED BY ENGINEERING

In a review of the past one hundred years of development in industry and engineering, certain considerations are outstanding. First, engineering is the basis on which the magnitude and rate of progress depend. Through the growth and application of scientific knowledge it has made the world a small place. It has increased the speed of travel by road, rail, air, and water; by means of rapid communication, it has eliminated time and distance; it has enabled the earth's resources to be made universally available; and it has been the means of providing for the growth and maintenance of populations with rising standards of living. Enormous strides have also been made in medical science, now almost universally available, not only in curing disease but also in preventing it and in improving hygienic standards. Similarly there has been an extension of the availability of all grades and phases of education. The wealthiest man in the community one hundred years ago had only a fraction of the amenities that everyone enjoys today. Hours and arduousness of labor have steadily decreased, thus providing leisure for cultural pursuits, physical recreation, and amusement.

It is sometimes said that human nature cannot control the machines which science and invention have produced, and that this inability is largely responsible for the present derangement of world affairs. Today there is a tendency, which the economic stress has served to emphasize, to regard industry as a service, as a means to an end, the end being the greater development of intellectual life and the raising of ethical standards. It is surely the responsibility of engineers, scientists, and industrialists to foster this spirit.

The Construction Engineer—The Centenarian

By W. C. HUNTINGTON

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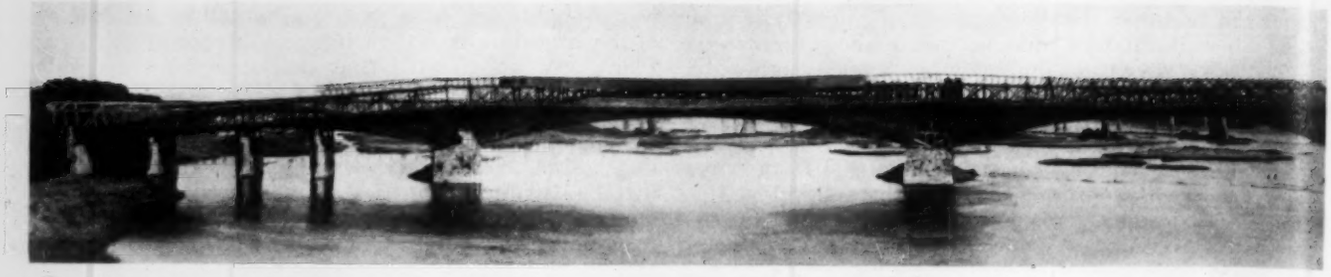
AT the close of the Revolutionary War, a century and a half ago, there were practically no engineering works of importance in America. The first step in the development of the vast, almost unexplored, area of this new republic was that of providing transportation facilities. At that time highways were not suitable for the transportation of goods, and since an extensive natural transportation system was provided by the long rivers and large inland lakes, the augmenting of this system by the construction of canals was the logical procedure.

In the early days of canal building there were few experienced civil engineers in America. The Erie Canal, which was later to be converted into the New York Barge Canal, was started in 1817. Supervision of the outstanding work was assigned to men with little if any engineering training or experience. During the construction of this project, however, many men secured the training that enabled them to continue the work of canal building and later to take charge of the construction of the early railroads, which practically brought canal building to an end.

During the whole period of the development of the transportation system of the United States, bridges have been required to carry railroads, highways, and even canals over the many rivers that traverse the country. Because of the abundance of timber and the scarcity of funds, timber bridges were built instead of the more expensive stone bridges used in Europe. As early as 1812, new types of timber bridges with clear spans up to



A WOODEN STRUCTURE OF A CENTURY AGO

Camel-Back Bridge at Harrisburg, Pa., Built in 1816 and Removed in 1902. Photograph Courtesy of J. C. Hoyt, M. Am. Soc. C.E.

340 ft were constructed, largely by judgment and experience. It was not until 1850 that the scientific principles of bridge design were developed.

A century ago, the selection of construction equipment was a relatively simple matter, for there was not much to choose from. At the present time, however, this phase of the work of the construction engineer is a perplexing one and requires a true appreciation of the actual cost of operating equipment. Development of a procedure for estimating, securing of cost data, planning of construction operations so that a project will be completed on time, and checking up on the rate of progress, is a task of the construction engineer.

CONSTRUCTORS OF OLD HELD RESPONSIBLE

The responsibility of a builder for the quality of his work was recognized in the oldest code of laws, that of Hammurabi, King of Babylonia, prepared about five thousand years ago. The public was protected against unskilled and unscrupulous builders by providing that, "If a builder has built a house for a man and has not made strong his work, and the house he built has fallen, and he has caused the death of the owner of the house, that builder shall be put to death."

Twenty-four centuries ago, the Greeks carved the contracts and specifications for important engineering works on slabs of stone and erected them permanently on the building site. These documents are similar in many ways to those of the present day. Public contracts were let to the lowest responsible bidder, who was required to furnish bond. The number of competent workmen to be furnished was sometimes specified, and the time of completion was fixed, penalties being imposed for failure to finish the work on time. Incompetent workmen were to be removed from the work, and in case of a disagreement the "judgment of the temple committee" was final.

One hundred years ago the construction engineer in America secured his training on the job, but there was no apprentice system. Gradually engineering schools were established, until now there is ample opportunity to obtain training in civil engineering. Only a small number of schools, however, give special consideration to construction engineering, which is really the construction side of civil engineering. As a result of the development of technical education, the construction engineers of the present day are commonly engineering graduates with construction experience.

In most respects, modern engineering works have far outstripped those of the ancients. But if the magnitude of construction operations is gaged by the number of men employed or even by the quantity of material placed, these modern works do not seem so outstanding when compared with the Great Wall of China, build 22 centuries ago, or with the Great Pyramid, which dates back 50 centuries.

PITTING WITS AGAINST NATURAL FORCES

The task of the construction engineer is not an easy one, but to many it is the most fascinating phase of engineering. Others may conceive the ideas, prepare the plans and specifications, and supervise the work, but the construction engineer is the builder. On plans it is a relatively simple task to show foundations carried down a hundred feet or more through quicksand to rock, but the construction engineer must actually deal with this treacherous material and build the foundations at the minimum possible cost. He must build bridge piers and dams in spite of floods and carry tunnels through mountains of treacherous rock and under rivers. Under his direction men must be housed and fed, their health must be guarded, they must be protected from injury, and their cooperation and loyalty must be secured. At all times he realizes that he must keep the costs down, maintain the quality of the work, and complete the job on time. The man on whom these responsibilities fall is the construction engineer.

A Hundred Years of Transportation

By F. G. JONAH

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NEARLY every means of transportation we enjoy today, and certainly every means of rapid transportation, has been developed in the past century. For a proper appreciation of the present, a clear perspective of the past is needed. Primitive man had no means of transportation until he learned to capture, tame, and domesticate animals, thereupon transferring the burdens of transportation from his own shoulders to theirs. The earliest writings make reference to the elephant, camel, horse, and ass used in both peace and war.

After many centuries the wheel was invented, when and where is not known, but with it man made one of his first great advances. Perhaps the three most im-

portant milestones in man's progress were the discovery of the art of making fire, the development of the alphabet, and the invention of the wheel. The wheel was first used in the carts and war chariots of the ancients; it is shown in the carvings and bas relief sculptures of the Assyrians and Egyptians that date back to 1500 B.C.

Many centuries passed with little or no improvement, but after a time the two-wheeled chariot was replaced by the four-wheeled covered wagon, and finally, when springs were introduced, by the coach. Coaches were first let for hire in London in 1625, when there were only twenty. Ten years later, however, they had become so numerous that Charles I issued an order limiting their number—one of the first cases of traffic regulation on record. The increasing use and improvement of the stagecoach led to a demand for better roads, which resulted in macadam highways in England and in some of the countries of continental Europe, making possible travel on quite an extensive scale. The use of the automobile has likewise led to a demand for better roads, and concrete highways have been developed.

ANCIENT EGYPTIAN CARRIAGE

In all this time, from the dawn of history to the beginning of the nineteenth century, there was nothing that could be called rapid transit. It is just a few years more than a century since George Stephenson, in 1829, demonstrated the success of his pioneer railway. Within the past few years we have seen the celebration of one hundred years of transportation on the New York Central and the Baltimore and Ohio railroads.

The first railway equipment was light, and speeds were from 15 to 30 miles an hour. The first coaches, which were short and very similar to the stagecoaches they supplemented, were of wood, with wooden benches for seats. They were heated with stoves and lighted with coal-oil lamps. Many of the improvements for comfortable rail travel were developed in this country, such as the air brake, automatic coupler, sleeping and dining accommodations, air conditioning, and electric lighting.

At the World's Fair in Chicago in 1893, the crowning exhibit in transportation was Engine 999 of the New York Central, which hauled the Empire State Express at 60 miles an hour. As illustrating the progress of one hundred years, this line may be taken as typical. The route from Albany to Schenectady was opened in 1831 with a train of three converted stagecoaches hauled by the DeWitt Clinton, an engine weighing 6 tons and making a speed of 15 miles an hour. In 1893 Engine 999, weighing 102 tons, made 60 miles an hour hauling the Empire State Express. On May 10, 1893, this engine steamed a measured mile near Batavia, N.Y., at the rate of 112.5 miles an hour, which I believe still stands as the record for a steam locomotive. The DeWitt Clinton and Engine 999 are on exhibition at the Century of Progress Exposition in the Travel and Transportation Building. The present passenger engines of the New York Central weigh 329 tons. The "Royal Scot," a famous British train, is also exhibited there. It has one of the fastest schedules of any steam train in the world and has traveled at 88 miles an hour.

EARLY WHEELED ASSYRIAN CHARIOT

The Germans have established the record for speed on rails—143 miles an hour. This was made with the propeller rail Zeppelin in 1931, between Berlin and Hamburg, on a long stretch of tangent track, but this speed was too fast for a track with curves. They now have a streamlined train electrically driven, Diesel motored, that makes a maximum speed of 100 miles an hour. A somewhat similar train will soon be in operation on the Union Pacific.

AN INDIAN DRAG AS USED IN NORTH AMERICA

Other speed records are:

An Italian airman	426 miles per hr
Sir Malcolm Campbell	272 miles per hr in a racing car on a Florida beach
Garfield A. Wood	124.91 miles per hr in a speed boat on the Detroit River

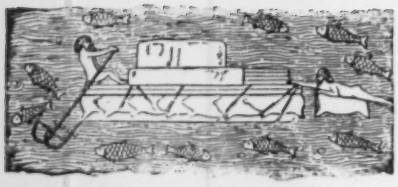
About forty years ago the electric railway was developed, with the result that electric traction soon became universally popular for urban, interurban, and suburban lines. But today the electric line is passing before the bus and the automobile. No doubt the future of electricity in the transportation field will be in the conversion of certain sections of steam railways to electric traction.

At the World's Fair in Chicago in 1893 there was no hint of the automobile, and at the World's Fair in St. Louis in 1904 it appeared as the "horseless carriage." Since that time the perfection of the internal combustion engine has practically revolutionized transportation on land.

WATER TRANSPORTATION DEVELOPED EARLY

It is not known when man first used the waterways, but it was doubtless at a very early date, for the ancient civilizations were developed along rivers and seacoasts. Possibly a raft was the first form of water-borne craft. Another ancient form was the raft buoyed up by inflated skins, which is still in use on the Tigris and Euphrates and elsewhere in the East. Another form is the wicket basket covered with pitch, the kind of vessel in which Moses was exposed on the Nile—still in use in Mesopotamia. It is known that boats were developed for extensive use at a very early date, for Egyptian inscriptions refer to them in 3000 B.C. For centuries water transportation was far in advance of transportation on land.

As regards rapid transportation by water, the development has been almost entirely within the last one hundred years. The first steamship to cross the Atlantic was the Savannah. In addition to side paddle wheels it had a full complement of sails, since the navigators of 1819 were not willing to trust entirely to machinery. Now we have great ocean liners furnishing the most luxurious form of all transportation and making a speed of 30 miles an hour. Fast steamship travel has meant



SKIN RAFTS FOR TRANSPORTING STONE ON THE TIGRIS RIVER, ABOUT 1000 B.C.

much to the progress of civilization, as it enables the products of different countries to be interchanged quickly. Contact between people of different lands has done much for the international friendships which we so highly prize and upon which the peace of the world so largely depends.

Man has longed to fly ever since he first beheld the birds wheeling above him, and in early mythology there are accounts of his having done so. There is the tale of Icarus, the Greek, who flew so close to the sun that the wax holding his wings melted so that he fell to his death in the sea. About 1147 A.D., Geoffrey of Monmouth wrote a history of the kings who reigned in Britain before the coming of the Angles and Saxons. He tells of King Bladud, the father of King Lear, one of Shakespeare's great characters. Bladud, a very ingenious man, practiced magic and tried to fly with wings. He went high into the air but was dashed to pieces by falling on the Temple of Apollo in the City of Trinovantum—that is to say, in London, where St. Paul's Cathedral now stands on Ludgate Hill. All down through the ages we read of attempts at flying. That versatile genius, Leonardo da Vinci, has left the drawings of his flying machine, which in outline closely resembles the monoplane of today. But at best the efforts of these early experimenters resulted in short gliding flights only.

FIRST BALLOON FLIGHTS

The first real flights were in balloons. On June 5, 1783, the Mongolfier Brothers released a small balloon, but it was in November 1783 that M. Francois Pitatre de Rozier made the first balloon ascension. This early development was in France. One of the most remarkable of the early flights was that made by James Wise and two companions on June 21, 1859. They went from St. Louis to Jefferson County, New York, 1,150 miles, in 19 hours, thus averaging 60 miles an hour. But ballooning could hardly be called navigation because the navigators were subject to air currents and winds. Their destination was never certain and could not be controlled. The internal combustion motor made the heavier than air machine possible. Within this present generation we have witnessed the entire progress of aerial navigation.

One hundred years ago transportation facilities were wholly inadequate, limited largely to movements on rivers and lakes, which were often icebound for months at a time. Today we have too much transportation.

What of the future? He would be a rash man indeed who would assert that we have reached the limit of development. When Jules Verne wrote *Around the World in Eighty Days*, *Twenty Thousand Leagues Under the Sea*, and *A Journey to the Moon*, they were regarded as fanciful and entertaining romances. But since that time many journeys have been made around the world in much less than eighty days—one in 8 days 15 hours. He also foresaw the submarine.

A POET'S PROPHECY

In Tennyson's "Locksley Hall," which was published in 1842, long before men had achieved flight, there is one of the most prophetic visions on record:

> For I dipt into the future
> Far as human eye could see,
> Saw the vision of the world,
> And all the wonders that would be.
>
> Saw the heavens filled with commerce,
> Argosies of magic sails,
> Pilots of the purple twilight
> Dropping down the costly bales.
>
> Heard the heavens filled with shouting,
> And there rained a ghostly dew
> From the nations airy navies
> Grappling in the central blue.

All this became reality in the World War. But Tennyson saw in his vision more than the airplane and aerial warfare, and let us hope that this part of his great prophecy will soon be fulfilled.

> For along the world-wide whisper
> Of the south wind rushing warm,
> With the standards of the peoples
> Plunging through the thunder storm.
>
> 'Till the war drums throbbed no longer,
> And the battle flags were furled,
> In the Parliament of Man
> The federation of the world.

One hundred years ago the country was being settled by God-fearing men and women, our pioneer ancestors, who laid the foundations of our present prosperity and culture. As we contemplate the hardships they endured, largely by reason of lack of transportation, we have for them a feeling of admiration and reverence, and we sometimes wonder whether we are worthy descendants of a people of such heroic mold.

Advances in Bridge Construction

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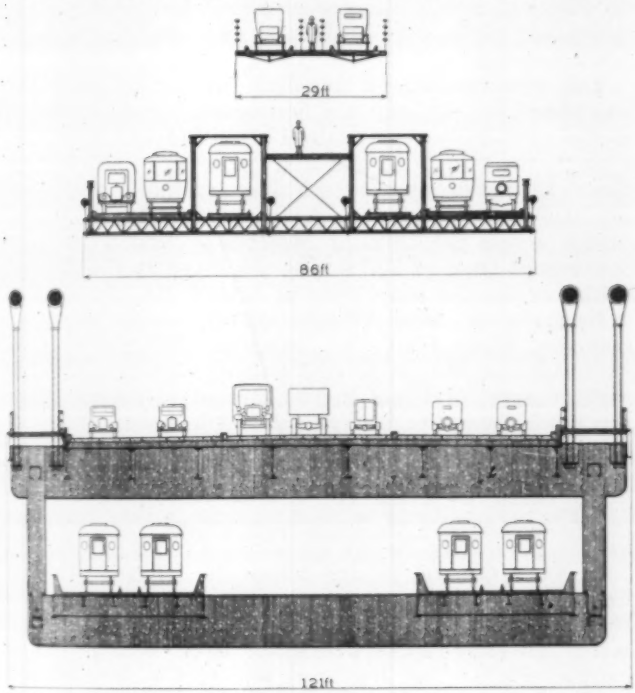
EVERY bridge of new magnitude presents new engineering problems. Increases in size, more particularly in length of span and carrying capacity, as well as in speed and economy of construction, can be taken as a general measure of progress in this branch of engineering. Viewed from this angle, progress in bridge construction in the historically short period of the past hundred years has been truly phenomenal. Remarkable as these achievements were for their time, the bridges built a century ago appear like pigmies beside the giants of today. Their detail design seems primitive, their materials low in strength, and the methods of erecting them slow and cumbersome when compared to the rapid, highly organized, and mechanized modern procedure.

A CENTURY OF PROGRESS IN THE CONSTRUCTION OF SUSPENSION BRIDGES
George Washington Bridge, New York, 1931; Brooklyn Bridge, New York, 1883; Menai Bridge, North Wales, 1826

Advances in the theory of structures, in research, and in experimental work, and improvements in materials, fabricating, and erection machinery give the modern engineer a distinct advantage. The accomplishments of the engineers of one hundred years ago and their followers are therefore all the more remarkable, and they must be credited with as much ingenuity, resourcefulness, thoroughness, and perseverance as present-day engineers may accord to themselves.

In a fundamental sense, the engineers of the past century have taken over the types of bridges handed



INCREASES IN SPAN AND CARRYING CAPACITY OF BRIDGES
George Washington Bridge; Brooklyn Bridge; Menai Bridge

down from former civilizations, even from primitive peoples, and have merely adapted them to new materials and refined their design. Nor can modern bridge engineering claim the introduction of essentially new methods of erection, not already proposed or practiced generations ago. Progress in erection methods has been due predominantly to the development of more efficient and powerful erection equipment, to economy in the utilization of temporary erection material, and to the extent to which the structural parts are manufactured in the shop.

Construction of the famous Waterloo Bridge across the Thames River in 1817 at a cost of nearly $5,000,000 and the rebuilding of London Bridge between 1821 and 1830 at a cost of approximately $10,000,000 involved great financial efforts for the city of London, which at that time had a population of about 1,500,000. In 1870 New York, with a population of about 2,000,000, was able to finance the construction of the Brooklyn Bridge, which cost in the neighborhood of $15,000,000. Today, with a population of 9,000,000, metropolitan New York can afford to spend not only $60,000,000 for a single bridge across the Hudson, but hundreds of millions for the almost simultaneous construction of several large crossings, bridges, and tunnels over and under the waters separating its various boroughs.

Technically, progress in bridge construction has been due largely to the development of the theory of structures and to knowledge of the properties of materials gained through extensive research work and experimentation. In this respect bridge building has developed during the century from an empirical art to a highly specialized science. The theory of elasticity was in its infancy a century ago. When Telford planned the Menai Bridge he developed the major forces largely on models. Bridge failures of that day resulting from inadequate design might be excused on the ground of insufficient knowledge; today the designer has no such alibi.

IMPROVEMENTS IN MATERIALS AND MACHINERY

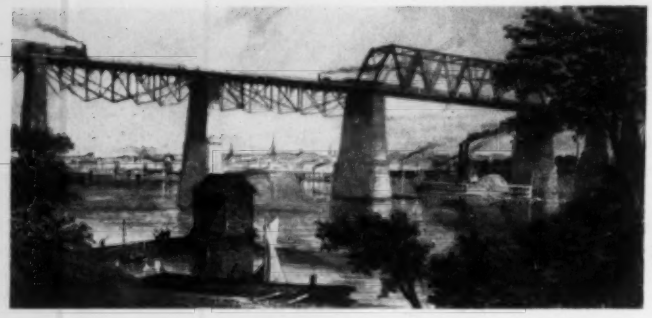
Perhaps the most important factor contributing to progress in bridge construction was the development and the economical mass production of the two artificial materials that now predominate in the field of bridge construction—steel and portland-cement concrete. At the beginning of the past century, stone, wood, and wrought and cast iron were the materials at the disposal of bridge engineers, but now they have practically disappeared as essentials for modern bridges.

The materials used for cables of suspension bridges, for instance, have been improved so that today they possess from three to four times the strength that was available early in the nineteenth century. The early chain cable links were of wrought-iron rods or bars, which had a strength of from 40,000 to 50,000 lb per sq in. Nickel steel eye-bars, with a strength of from 85,000 to 100,000 lb per sq in., were used for the first time in 1902 in the tension chords of the Queensboro Bridge in New York. Heat-treated non-alloy eye-bars with strengths up to 105,000 lb per sq in. have been used in a number of bridges.

The strength of wire has increased to an even more marked degree. Wrought-iron wire in the early French suspension bridges had a strength of from 60,000 to 70,000 lb per sq in. In the Niagara Bridge, completed in

1855, the late John A. Roebling, M. Am. Soc. C.E., introduced charcoal iron with a strength of 115,000 lb per sq in. Steel wire, with a strength of 160,000 lb per sq in., was used for the first time in the Brooklyn Bridge. For the George Washington Bridge the wire was specified to have an average minimum strength of 225,000 lb per sq in., but the actual average was close to 235,000.

Coupled with this great increase in unit strength of wire was the gradual increase in size of cables, made practicable by improved methods of construction. Thus the united strength of 1,500,000 lb for the four $5^1/_4$-in. cables in the Freiburg Bridge compares with the strength of 18,000,000 lb for the four 16-in. cables of the Brooklyn Bridge, and with 180,000,000 lb for the four 36-in. cables of the George Washington Bridge.



OHIO RIVER BRIDGE AT LOUISVILLE, KY.
A Simple Truss with a 400-Ft Span, Built in 1868–1870

Only 25 years ago portland-cement concrete with a compressive strength of from 2,500 to 3,000 lb at 28 days was considered of excellent quality for concrete arches; whereas in some of the large reinforced concrete arches recently built, strengths of 5,000 lb and more have been secured.

Hand power and the forge, together with primitive hand-operated hoisting tools, were the principal equipment in the construction of iron bridges a century ago. Practically all the work of assembling and connecting was performed at the bridge site. Individual members did not weigh more than a few hundred pounds. Today the fabricating shops, equipped with power-operated punches, drills, shears, planers, and riveters turn out completely assembled members weighing 150 tons and more, and at the bridge site powerful electric hoists lift such pieces into position at a great height in very little time.

ARCH BRIDGES OF STONE AND CONCRETE

With a span of 200 ft and a rise of only 42 ft, the Grosvenor Bridge, a stone arch over the River Dee at Chester, England, is one of the outstanding bridges of its type built a hundred years ago. Like all earlier stone arches, it has a single massive arch barrel the full width of the bridge. It was not exceeded in span until 1864, when General Meigs completed the famous Cabin John Bridge, whose 220-ft span carries a roadway and an aqueduct over Rock Creek, near Washington, D.C. Today the longest bridge of this kind crosses the Syra Valley at Plauen, in Saxony, with a 300-ft span.

With the advent and improvement of reinforced concrete came the opening of a new field of magnitude for the massive arch. Ten years ago the United States led the way in this field with the construction of a 400-ft arch, the Cappelen Memorial Bridge, across the Mississippi River at Minneapolis. This has since been surpassed by the 460-ft span of the George Westinghouse Bridge in Pittsburgh, completed in 1931. But in 1930 French engineers pushed the record far ahead by completing a bridge across the Elorn between Brest and Plougastel, which carries a railroad and highway on a double deck over three comparatively flat arches, each of which has a clear span of 600 ft.

Up to the end of the nineteenth century, falsework for arched spans consisted generally of a veritable forest of wooden posts and bracing, although remarkably well-built wooden arch centers, without intermediate supports, were used over a century ago, as for instance for the famous Waterloo Bridge in London. In recent years steel centers in the form of arch trusses, with or without intermediate support, made their appearance. Perhaps the boldest procedure so far adopted was used in the erection of the three 600-ft arches of the bridge at Plougastel just mentioned, for which wooden falsework arches were erected on pontoons and floated from span to span.

GIRDER AND TRUSS BRIDGES

In Europe the forerunner of the modern truss was the solid-web iron girder. The Britannia Bridge, built by Robert Stephenson during the years 1845 to 1850, with two continuous spans of 460 ft, is outstanding among early iron bridges. It was the first bridge of its type built entirely of wrought iron and is remarkable in its conception as a complete plate-girder tube, and also in its erection, which was accomplished by floating whole spans into place. It is still in service, carrying a single-track railroad.

The structure across the Ohio River at Louisville, completed in 1868, was the first outstanding iron bridge of the open-truss type in the United States. It carried a single-track railroad and had spans up to 400 ft long. Since then the span length has gradually increased. By 1917 a simple span of 720 ft was used in the railroad bridge across the Ohio at Metropolis, and a two-span continuous truss of 775 ft was employed in the railroad bridge across the same river at Sciotoville.

Erection of truss bridges on falsework has been common throughout the century. With the more extensive use of rigid riveted trusses, capable of temporary reversal of stress in the tension members during erection, came the use of falsework bents or towers spaced considerable distances apart, the trusses being cantilevered from one support to the next, and the same posts being used for the successive supports. Outstanding examples of the application of this procedure are the Sciotoville Bridge across the Ohio River and the New York Central Bridge across the Hudson River at Castleton, in which the trusses were cantilevered more than 400 ft and the temporary supports were entirely of steel. In some cases whole spans have been erected by cantilevering, either from one pier to the next or from both piers to the middle, without intermediate supports. Adjacent spans acted as temporary anchor arms in such cases.

The floating and raising into position of the suspension span of the Quebec Bridge is the most outstanding modern example of this kind of erection and one that furnishes an interesting comparison with the quite similar erection of the Conway and Britannia bridges. The first span so erected for the Conway Bridge was 400 ft long and weighed about 1,200 tons. It was lifted from the barges by four 400-ton hydraulic jacks. The pontoons that carried the span started on the journey from the shore nearby on March 6, 1848; the lifting to a height of 60 ft was begun on April 8 and completed on April 16—a total performance time of 40

days. In 1917 the suspension span of the Quebec Bridge, erected on shore 3½ miles below the site and weighing 5,400 tons, was floated and lifted to a height of 150 ft in five days by means of eight 1,000-ton hydraulic jacks.

One hundred years ago metal arches, then built of cast iron, did not exceed the 240-ft span of the Southwark Bridge over the Thames, built by John Rennie in 1819, although as early as 1801, Telford had proposed to rebuild the old London Bridge using a single cast-iron arch of 600-ft span. A bold advance in metal-arch construction was not made, however, until 1874 when, after six years of work, the late James B. Eads, Fellow Am. Soc. C.E., completed the famous bridge across the Mississippi River at St. Louis. This structure has a center span of 520 ft and two side spans of 502 ft. It was the first arch built of steel, also the first arch that carried railroad traffic, and for over twenty years was the longest arch span.

In 1917 the 1,000-ft span of the Hell Gate Bridge, which carries four heavy tracks across the East River in New York, N.Y., set another record. It is one of the few masterpieces of modern bridge engineering as well as of bridge architecture. It is the heaviest bridge per foot so far built, carrying a total load of 75,000 lb per ft, five times that carried by the Eads Bridge. In 1932 both the Sydney Harbor Bridge in New South Wales and the Bayonne Bridge across the Kill van Kull in New York, the two longest existing arches, were completed. Both have nearly identical spans of about 1,650 ft, but neither approaches the Hell Gate arch in weight and carrying capacity.

The early cast-iron arches were erected on falsework, but the cantilever method, with wire rope or structural steel backstays, to which the steel arch is so well adapted, has found favor in most of the large arch bridges built since 1845. In the Sydney Harbor Bridge wire ropes anchored in rock tunnels were used as backstays, and each half arch was cantilevered out to the center, a distance of 825 ft.

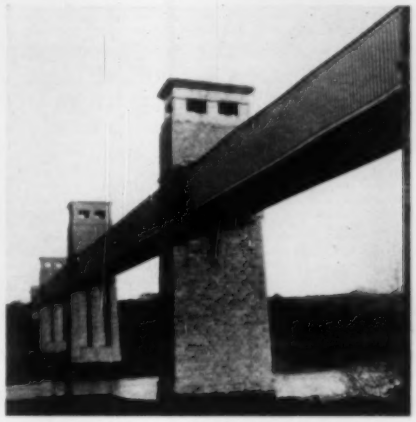
CANTILEVER BRIDGES

The cantilever did not develop as a modern type of bridge until 1866, when it was first used in the structure across the river Main at Hassfurt, Germany, with a central span of 425 ft. In the United States the late Charles Shaler Smith, M. Am. Soc. C.E., used this type for the first time in 1876 for the Kentucky River Bridge of the Cincinnati Southern Railway, with three spans of 375 ft each. Due to its rigidity and economical adaptation to long spans for railroad service, the cantilever soon came to outrank all other types in length of span.

In 1890, after nine years of construction, the late Sir Benjamin Baker, Hon. M. Am. Soc. C.E., completed a cantilever bridge across the Firth of Forth having two main spans of 1,710 ft and a total length of bridge proper of 5,350 ft. It carries two railroad tracks at a clear height of 150 ft above the water. Its magnitude, its majestic appearance, and its clear expression of the cantilever principle have not been surpassed in any other structure of this type, although in length of span and capacity it is now outranked by the St. Lawrence River Bridge at Quebec, which has a main span of 1,800 ft and the capacity to carry two heavy railroad tracks and a roadway.

SUSPENSION BRIDGES

The climax of development to date has been reached in the building of suspension bridges, the type par excellence for long spans. In 1826, after it had been in process of construction for seven years, Thomas Telford completed the famous suspension bridge across the Menai Straits at Bangor in North Wales. It was then unquestionably a remarkable achievement in bridge engineering, not only because of its unprecedented span of 580 ft but because of many other extraordinary features, its splendid conception, and its ingenious erection. It still stands after having given more than one hundred years of useful service, whereas many later and more modern structures have disappeared. It carries on a single deck two vehicle roadways and a footwalk.



BRITANNIA BRIDGE, WALES, BUILT 1844–1850
A Continuous Tubular Girder with a Span of 460 Ft

In 1834, or only eight years after the Menai Bridge was completed, the French engineer, Chaley, erected a suspension span of 870 ft across the deep valley of the Soane in Freiburg, Switzerland. This span held the record for 13 years, after which there followed in rapid succession a number of highway suspension bridges in the United States, notably those at Wheeling, W. Va., Cincinnati, Ohio, and two across the Niagara River, with spans ranging between 1,000 and 1,260 ft. In 1883 a new milestone was set by the completion, after 13 years of construction, of the Brooklyn Bridge across the East River in New York. The fiftieth anniversary of this achievement was appropriately celebrated on May 26 of this year.

As early as 1867, John A. Roebling declared that, with the iron wire then available, a suspension bridge of 3,000-ft span would be practicable for a crossing of the Hudson River. It was not until 1931 that, after only 4½ years of construction, the George Washington Bridge across the Hudson River, with its span of 3,500 ft, established a new record of magnitude that doubled the previous one in span length.

GOLDEN GATE BRIDGE TO HAVE LONGEST SPAN

Already the supremacy of this bridge is challenged by that now under construction across the Golden Gate in San Francisco which, while having less than half the capacity of the George Washington Bridge, will exceed it in span by 700 ft.

Thus, within about one hundred years, the greatest suspension spans will have increased over sevenfold, from 580 to 4,200 ft. But more significant, as reflecting the magnitude of both span and capacity, is the enormous increase in the weight freely suspended between the towers. This amounts to about 650 tons in the Menai Bridge, 8,120 tons in the Brooklyn Bridge, and 68,300 tons in the George Washington Bridge. In spite of the enormously greater mass and size of the latter, its construction required only two-thirds the time consumed for the Menai Bridge and one-third of that needed for the Brooklyn Bridge.

Suspension bridges, at least the main suspended structures, have been erected since early times and, with few exceptions, without the use of temporary falsework. In fact, their adaptability to such erection is one

of their major economic characteristics. As the span length and size of wire cables increased, the method of erection by raising them offered certain disadvantages. Strands of parallel wire were difficult to handle, and twisted wire ropes did not develop the high strength of parallel wires. In the building of the Niagara Railway Bridge, Roebling introduced the so-called aerial spinning process, which consists in pulling loop after loop of single wire across the river, from anchorage to anchorage over the towers, by means of a traveling wheel. The wires are laid up in strands, which on completion are compacted together into a cylindrical cable and tightly wrapped with wire. This process has proved so successful that it has been adhered to, without change in principle, in all the large wire-cable suspension bridges since built. Spinning the 3,600 tons of cable wire for the Brooklyn Bridge consumed 21 months, the 6,400 tons for the Manhattan Bridge, 4 months, and the 28,100 tons for the George Washington Bridge, 10 months.

After this review of the remarkable developments in the field of bridge engineering in the past century, a brief forecast of the future may be ventured. In the present lull there may be an inclination toward pessimism as to the possibilities that lie ahead, but those who keep their ears to the ground can readily observe that even now the way is being paved for new developments. New theories are in the making that will enable engineers to penetrate still further the intricate stress conditions in a structure. New materials higher in strength or lower in weight are already competing with the older ones. New processes of fabrication, of which welding has already gained wide application, will revolutionize design and construction. And with these improved methods there will be opportunities for still greater achievements.

Water Terminals of Yesterday and Today

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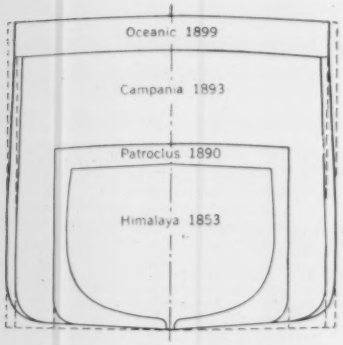


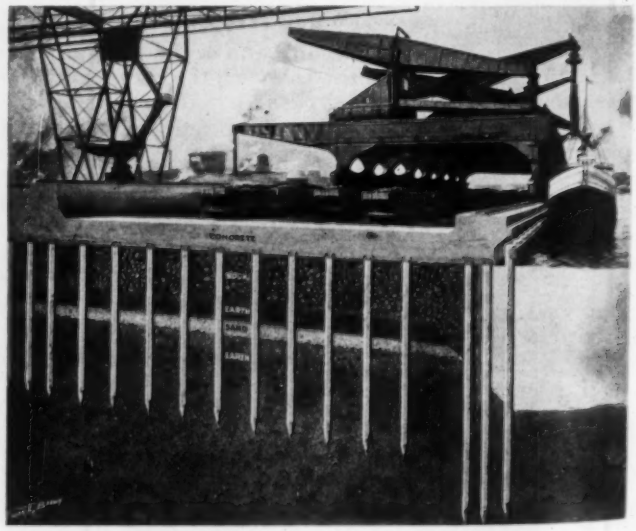
FIG. 1. GROWTH IN SIZE OF TYPICAL VESSELS
Adapted from *Dock Engineering* by B. Cunningham

ONE hundred years ago Andrew Jackson was filling his second term as President. The rallying cry of his campaign had been that he was not a college graduate—a cry typical of the time, the first quarter of a century after Napoleon's defeat. It was a period of peace, when the democracies of Europe and America were struggling to make something of themselves, with the result that marvelous progress was being made in the knowledge, comfort, and power of the common people. Many of the industrial changes that have since revolutionized the world had their beginnings in that era. Fulton had given America the first practical steamboat; the Erie Canal had been completed and opened to traffic from the Great Lakes; Stephenson was giving the world railway locomotion. With steamships, railroads, and canals coming into use, the real development of the water terminals commenced.

Natural harbors had been used since ancient times but it was left to the century under review to create great works of dock and harbor engineering. A century ago all the ships were small and built of wood. They did not carry heavy loads. The problem was to take care of an increasing number of small ships rather than a smaller number of large ones. Like the numerous sailing ships which continued to be used for commercial purposes, the early steamboats had moulded hulls and therefore did not require deep water close to the docks. Hulls were short and stout, with thick sides, and if they grounded because of lowered water level, no harm was done. Little dredging was needed.

Along the banks of most rivers it was possible to construct a dock by driving wooden piles into the bottom, using a cast-iron hammer raised in leads by men on a hand rope or by a horse. Parallel rows of piles capped with a timber platform gave all the strength needed. The timber work of the dock was done entirely by hand with a saw, chisel, auger, and adze. The warehouses were generally one-story sheds. There were no heavy unloading cranes or conveyors to support; freight was carried over the ship's side on men's backs.

Soon steam engines were used to raise the drop hammers for pile driving. About 1840, James Nasmyth invented the steam hammer. Where there was a hard bottom, docks, breakwaters, and piers were formed of wooden cribs filled with stone. These were built either of round logs or hand-hewn square timbers. In fact, hand construction was used throughout. Steamboats came into more general use during the forties and



MODERN ORE DOCK UNDER CONSTRUCTION
For Pennsylvania Railroad Company at Cleveland

DIESEL-ELECTRIC DIPPER DREDGE DIGGING BLASTED ROCK IN THE EAST RIVER, NEW YORK
Drill Boat and Hell Gate Arch in Background

fifties, although sailing ships continued to carry the bulk of commerce, particularly on long trips such as to China for tea. The period from 1843 to the Civil War was the era of clipper ships but many of these were sunk by privateers during the war, and the new ships built were steam driven, with iron hulls. They followed the shape of the old moulded models but had thin plates and greater weight so that they would suffer from ground-

STONE FILLED SHEET-PILE BREAKWATER
Lincoln Park Extension, Chicago

ing. It was vital to have sufficient water beneath them at all times. Dredging close to dock fronts became more important, hence docks had to be made stronger.

By 1883, or fifty years ago, the largest boats had a gross weight of 5,000 tons and needed 24 ft of water. By 1891 ocean-going boats required 27 ft of water, had increased in weight to 7,000 tons gross, and were 500 ft long. Steel boats had come to stay. They no longer had a deep external keel but approached the box section of today, shown in Fig. 1. The face of all docks had to be strictly vertical. This necessitated deep water close to the dock front, which, with the loads behind it, further increased the strains on the dock. For sinking piles in sand, the water jet run by a hand pump was coming into use. On water-front work for the World's Fair in 1893 the modern water jet, with a pressure of 100 lb per sq in., was employed with success.

Then came the era of concrete. In 1899 one of the first concrete docks in America was constructed at the ore terminal in South Chicago. The slag cement, made in a shed on the premises, was mixed in a worm or screw concrete mixer with steam power and chain drive instead of by hand. The first mechanical ore unloader was constructed on the concrete dock and is still in service.

Reinforced concrete piles of the premolded type and concrete sheeting came into the picture a little later. The Pennsylvania ore dock built in 1912 on a reclaimed lake bed at Cleveland is an example. Its piles were cast vertically in steel forms during the winter season and cured with live steam. Drop hammers weighing 5,000 lb did the driving.

In 1914 the Panama Canal was completed. It caused a great development in large steam dipper dredges. Trade routes shifted to New Orleans, which responded by creating modern water terminals.

The World War tested the country's water terminals. New York was called on to handle two billions of ship tonnage a year and did it, but the congestion was enormous. Seattle suddenly became the second port of the Nation, since it was the closest American port to the Orient and was well prepared with harbor facilities. Constructing the Army bases at South Brooklyn and at Philadelphia presented problems of size and speed. At South Brooklyn dipper dredges dug the boat berths for a 35-ft draft, and scows dumped the material at sea. At Philadelphia hydraulic dredges pumped the material ashore to fill low land.

Since the War, steel sheet piling has come into use for dock building. On the Great Lakes, piers and breakwaters of two rows of steel sheet piling with a stone fill between, have been built in the past few years. The last word in docks at present seems to be a combination of steel sheet piling anchored by steel rods protected against deterioration, and a concrete superstructure resting on wood or concrete piles. Skilled crews work 8 hr a day, using double acting steam hammers, water jets, portable air compressors, acetylene cutters, electric

welders, rod pushers (to eliminate trench digging), gasoline tractors or Diesel cranes (for excavating or backfilling), and gasoline-driven paving mixers served with dry batched concrete, to which metered water is added. The greater part of the floating equipment used at the present time has steel hulls.

MODERN DIPPER DREDGE EXCAVATING SHALE ROCK
In Ashtabula Harbor, Ohio

Since most water terminals are now in densely populated cities, construction problems are more complicated. Because soft coal smoke is considered a civic nuisance in Chicago and is penalized by fines, the largest marine construction company started ten years ago to build dredges, derricks, and tugs of the Diesel and oil-burning types. Twenty-one such pieces of equipment have been placed in service to date.

In ocean liners and in lake freighters the limit of size appears to have been reached. To the man on the street it might seem that all the problems connected with water terminals are solved. But engineers know that a water terminal has developed into something more than a safe place to tie up a ship. The problems remaining are vast. They involve economical cargo handling; cargo and passenger transfer by railroad, barge, car-ferry, motor, and airplane; warehousing; port equipment; and the "turn around" of ships. At no two ports are the needs identical. The great problems of the century now passing have been solved by American engineers and contractors in a way which promises that the present tasks will be met with the ability and cooperation that forbid despair.

Development of Industrial Buildings

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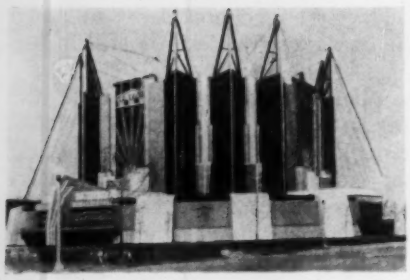


TRAVEL AND TRANSPORT DOME, CHICAGO
Century of Progress Exhibition

PROGRESS in building construction during the past one hundred years may be attributed to several fundamental inventions and discoveries. Perhaps no one thing has contributed more to it than the introduction of some form of iron as a structural element. The cast-iron beam with one flange, first used in 1801, and the Tredgold beam with two equal flanges were discarded in 1827 in favor of the improved cast-iron section, with a narrow compression flange and a wide tension flange.

A remarkable structure erected in 1851 was the "Building for the Exhibition of the Works of Industry of All Nations" in Hyde Park, London. It was 1,851 ft long (corresponding with the year), 450 ft wide, and had a frame entirely of iron, without supporting walls. There were 3,300 cast-iron columns and 3,352 iron beams and girders. The roof and walls contained 900,000 sq ft of glass and gave it the name of "Crystal Palace." The height to the crown of the arched roof of the transverse aisle was 104 ft, and the span of the wooden arches was 72 ft. Its five acres of gallery floors were supported by one-piece cast-iron girders 3 ft deep. Longer girders of 48 and 72-ft span were also 3 ft deep and had two wrought-iron angles for their top flanges and wrought-iron bars (or flats) for their bottom flanges.

Two items of historic interest appear in old files of the *Minutes of the Proceedings of the Franklin Institute.* The first, for the meeting of November 28, 1866, describes an 11-story "house," including two basements, in the course of construction in Paris. A unique feature was a "platform ascending noiselessly every minute and raised by hydraulic power"—evidently the forerunner of our modern passenger elevator. Less than a year later this publication noted another innovation, this time for a New York building, "the supporting principle being a wrought-iron frame of columns and girders." If this structure was built in 1867, it certainly would claim the distinction of antedating the earliest of the skeleton-frame buildings erected in Chicago in the eighties.

From 1884 on, progress in the use of steel to supplant cast and wrought iron was rapid, and by the time of the Chicago World's Fair in 1893, steel had practically taken

MAIN AISLE OF THE CRYSTAL PALACE, LONDON, IN 1851
From a Steel Engraving in the Crerar Library, Chicago

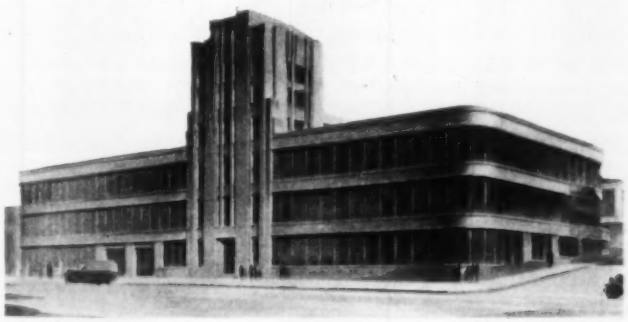
the place of these structural materials in the construction of buildings.

The combination of rolled sections of iron to form columns was early recommended by manufacturers. A special shape, called a Z-bar, was proposed by Charles L. Strobel, Hon. M. Am. Soc. C.E., about 1890, to be used for columns. These immediately came into general use for buildings because of their simplicity of form and connections.

With the rapid development in the production of iron and steel after 1883, there was scarcely any limit to the possibilities in the structural design of buildings. For obvious reasons, industrial buildings did not grow to great heights, but office buildings, apartment houses, and hotels soon began to soar skyward.

When the height of buildings began to exceed 10 stories, the entire basement space became filled with massive pyramidal foundations of masonry. In 1890, by introducing steel rails, and later, steel I-beams in the form of grillages embedded in concrete, foundations were designed having much less depth and weight for the same spread. Consequently it became possible to add one or two stories as well as to gain a usable basement space.

MONADNOCK BLOCK, CHICAGO, IN 1892
A 17-Story Wall-Bearing Building



MODERN INDUSTRIAL BUILDING WITHOUT WALL COLUMNS
Cashman Laundry Corporation, New York, N.Y.

A unique building was erected in Chicago in 1891–1892 on spread footings. This, the Monadnock Building, is probably the first, last, and only 17-story building in the world with bearing walls.

The party-wall foundations of the Chicago Stock Exchange Building in Chicago were designed and built under the direction of the late William Sooy Smith, M. Am. Soc. C.E. The concrete shafts, 5 ft in diameter, were carried down to hardpan, where they were expanded to 7½ ft in diameter. This was apparently the first foundation of this design, which has since become standard practice. Another later and improved type of foundation, used especially in the East, is a group of hollow pipes driven to very great depths and excavated by blowing out the sand or clay by pneumatic or hydraulic means, and then filling with concrete. A still newer type of foundation utilizes a large pipe driven and then excavated by an auger device and a drill into bedrock. After placing a steel disk on the rock, for a base, a long steel column of suitable section is lowered down the pipe and fixed precisely in position. Thereupon the pipe is filled with concrete.

One of the greatest developments of structural steel dates back to 1896, when Henry Grey, of Duluth, Minn., made application for a patent for a new and improved method of rolling wide-flanged I- or H-beams with a uniform thickness of metal. Failing of recognition, he was induced to leave the United States and to superintend the building and operating of a mill in Germany, where these beams were first commercially rolled.

Immediately they became a success. Mr. Grey then returned to the United States and directed the building of a mill at Bethlehem, Pa. As a consequence, the now well-known Bethlehem girder beams and H-columns were put on the market about 1907, or 11 years after he had made application for his original patent. Later the Carnegie Company took up the rolling of similar sections. Since then these sections have largely displaced others in general use.

Truly it would appear that the Grey sections have revolutionized structural steel practice in building construction. Probably no more striking illustration of this fact is possible than the adaptation of one of these sections, the Carnegie 36-in. girder beam, by shearing its web and forming it into an arch girder to make a single-piece arch roof member for a span of 160 ft, used to support the roof of the field house of the University of Chicago, erected in 1931.

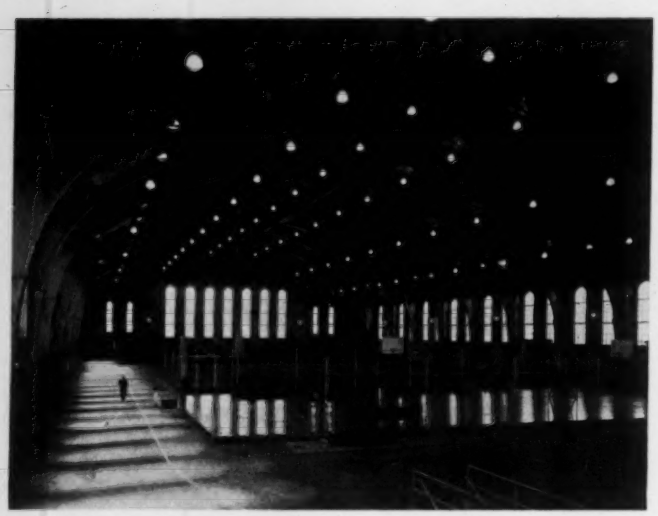
Welding of parts and connections in structural steel for buildings has not yet been generally recognized under city building ordinances, although there is really no reason why such welding cannot be so safeguarded as to permit its general use. Soon it may replace the present noisy riveting methods.

At first the same structural elements that had characterized wood and iron construction were reproduced in reinforced concrete. These included columns, girders, floor beams, and slabs.

It was in January 1905 that C. A. P. Turner, M. Am. Soc. C.E., filed an application for a patent on what, apparently, was the first so-called "flat-slab" floor construction. His "mushroom flat slab" reinforcement consisted of a combination of bent bars extending up and out radially from a column head, on which were carried a series of concentric rings of bars. Passing over these umbrella-like forms of bars, were four belts of smaller bars extending from column to column directly and diagonally. This arrangement did away with beams and girders, making a much shallower floor construction.

In 1907, Frank F. Sinks, M. Am. Soc. C.E., introduced a type of flat slab that had no reinforcing bars within the flare of its column heads. The slab was reinforced by main belts of bars extending directly over and between

the column heads in two directions only, and hence there were only two layers of bars over each column head. He provided two intermediate belts in each panel, parallel to the main belts and crossing each other near the bottom of the slab at the center of the panel. It was



UNIVERSITY OF CHICAGO FIELD HOUSE
Arch Beams of 160-Ft Clear Span Support Roof

his theory that a flat slab, so reinforced, could be resolved for purposes of stress analysis into main belts and intermediate belts and considered as made up of ordinary slab units, or wide shallow girders subject to the usual bending moments and shears.

Many flat-slab buildings have been built on the Sinks system since 1909, when the first structure of considerable magnitude, known as the Studebaker Building, was erected in Chicago. After a number of years, flat-slab construction practically replaced all other concrete forms for industrial buildings. Its benefits are many: not the least of them are reduction of story heights and improved distribution of light due to the elimination of beams. It also simplifies the installation of sprinklers and other equipment.

NEW AND UNUSUAL CONSTRUCTION

At all times during the past century ingenious minds have striven to produce designs and materials that would reduce the cost and weight of building construction and at the same time preserve adequate strength and stability. These efforts have resulted in great modifications in iron and steel shapes. Pressed steel and other variously formed light-weight sections to replace rolled steel sections have been introduced, and many very interesting developments have taken place. The buildings of the Century of Progress Exposition are admirable illustrations.

In 1929 there was erected in St. Louis an exposition building which was 470 ft long by 278 ft wide and had a seating capacity of 21,000 persons. The roof, of 155-ft span, was a wooden arch of the Lamella type, supported on steel cantilever trusses. In the Lamella system of roof construction, units of Douglas fir, nominally 4 by 18 in., are fitted together diagonally to form a lattice. The units are placed on edge and have steel-plate brackets at the joints.

The Central Engineering Laboratory, 11 stories high and 220 by 120 ft in plan, erected in 1930 by the Westinghouse Electric and Manufacturing Company, was the twenty-fourth welded steel building erected by that company after its first experience with this type of construction in 1926.

The circular Travel and Transport Building of the Century of Progress Exposition at Chicago has a clear interior diameter of 200 ft, its dome formed within a ring of 12 steel towers or braced columns 150 ft high, having their bases and their tops in a circle that is 212 ft in diameter. At the tops of the columns are attachments for suspension cables and for the anchors, or backstay cables. The tops of the columns may deflect as much as 8 in. under live-load changes; hence rocker bearings are provided at the bases. Load changes will also cause a downward deflection of the dome roof of almost 3 ft at the crown.

A modern application of reinforced-concrete flat-slab construction to an industrial building is the structure of the Cashman Laundry Corporation in New York, N.Y., designed by R. G. and W. M. Cory, architects and engineers, and built by the Turner Construction Company in 1932. The special features are: first, absence of wall columns, as the floors are cantilevered 8 ft 9 in. beyond the outer lines of the columns to permit the installation of continuous ventilating window sash; and second, the elimination of six columns in the first story by placing deep girders over the roof and suspending the columns above the locations of the six omitted first-story columns.

Notwithstanding the great advances that have been made in building construction and in fire protection, fire losses in the United States still take a terrific toll from the community. During the past six years these have averaged $460,000,000 per annum, or $3.81 per capita. Much remains to be done in the way of eliminating obsolete buildings that are a constant menace to nearby property because of their inflammable character.

Sound Control in Buildings of the Future

By PAUL E. SABINE
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IN considering the problem of sound control as it relates specifically to the buildings of the future, the physical nature of the phenomenon that is to be controlled should be understood. Attention should be paid particularly to the quantitative relations involved and to the recently developed terminology of acoustical engineering.

Sound may be defined as any pressure variation in the atmosphere that is capable of stimulating the hearing sense. Fundamentally, therefore, the practical aspects of sound control will be connected with the performance of the ear as a sound-detecting instrument. Sound originates in the gross mechanical vibrations of some material body and is propagated as compressional waves with a velocity, at usual temperatures, of about 1,120 ft per sec.

Sounds may be classified roughly either as musical

sounds or noises. Musical sounds or tones are produced by more or less sustained periodic vibrations of harmonic type and are characterized by definite frequencies, which determine the pitch sensations they produce. Noises differ from musical sounds in not having any very definite pitch and in having components whose frequencies bear no simple or fixed relation to one another. Any undesired sound, musical or otherwise, is ordinarily spoken of as a noise.

The frequency range of normal auditory experience extends from 20 to 20,000 vibrations or cycles per second. Subaudible vibrations may give rise to audible sounds by exciting higher frequency vibrations that fall within the audible range.

The physical intensity of sound is measured by the energy transmitted per second through a unit cross section of the sound wave. Even in the case of painfully loud sounds, the amount of energy transmitted is minute. It has been estimated that a football crowd of 20,000 yelling at full lung capacity for two hours would generate in that time barely enough sound energy to heat the water for a single cup of tea at the end of the game. The intensity of a barely audible sound vibrating at 1,000 cycles per sec is about 2×10^{-16} watts. In other words, the ratio of the intensity of a painfully loud sound to one that is barely audible is something like 50 trillion to one. The sensitivity of the ear to vibrational stimuli is so great that a quiver of the air with an amplitude of about one-third the diameter of a nitrogen molecule is sufficient to produce an audible sensation. This tremendous intensity range explains the difficulties to be overcome in jobs of practical sound insulation.

To avoid the use of unwieldy figures, acoustical engineers have employed a logarithmic scale on which to express the relative intensity of sound, called the decibel scale. The difference in decibels between two sound levels is ten times the logarithm of the ratio of the physical intensities of the two sounds. Thus, if the ratio of two intensities is 100 to one, the difference in intensity levels is 10 times the logarithm of 100, or 20 decibels. In Table I are given approximate values for various noise intensities above the audible threshold, expressed in decibels.

TABLE I. INTENSITY OF VARIOUS NOISES ABOVE AUDIBLE THRESHOLD

INTENSITY LEVEL, IN DECIBELS, ABOVE AUDIBLE THRESHOLD	PHYSICAL INTENSITY	EXAMPLE
0	1	Barely audible sound
10	10	Whisper at 1½ m
20	100	Quiet room
30	1,000	Quiet office
40	10,000	Quiet conversation
50	100,000	Noisy office
60	1,000,000	Loud conversation
70	10,000,000	Loud radio music
80	100,000,000	Very loud radio music or subway train
90	1,000,000,000	Pneumatic drill at 10 ft
100	10,000,000,000	Airplane motor at 10 ft

Sound consists of vibrational energy in the air, minute in quantity when expressed in terms of ordinary energy units, but in general very large when measured in terms of the minimum energy necessary for audition. As a practical matter, the frequency range from 100 to 5,000 cycles per sec is all that need be considered. The intensity range is from about 10,000 mu w (microwatts) to two ten-billionths of a microwatt.

By controlling sounds in buildings is meant ensuring, first, that useful sounds will produce the desired auditory effects and, second, that unwanted sounds will be reduced below the annoyance level. Under the first head is included the problem of providing rooms with good acoustic properties. Under the second, engineers are concerned with the reduction of noise that originates within the room, and with preventing the transmission of sound from out-of-doors or from other parts of the building.

THEORY AND PRACTICE OF ACOUSTICS

The study of the acoustic properties of rooms was first undertaken in a scientific manner some forty years ago by Wallace C. Sabine, of Harvard University. As a result of his work and that of followers of the principles and theory that he established, it can be said that there is no more excuse today for poor acoustics than for poor lighting or bad ventilation.

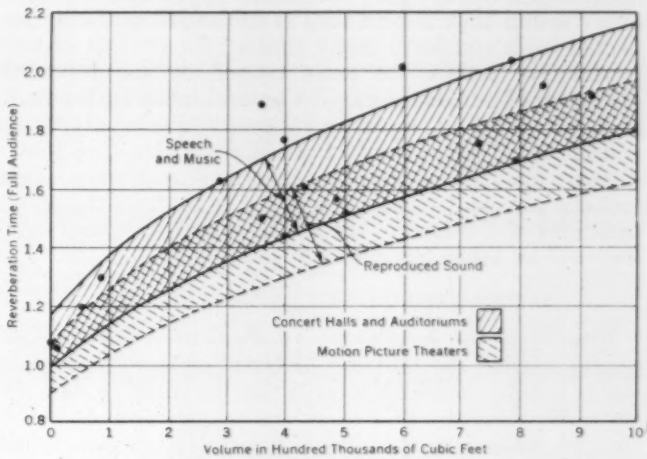

FIG. 1. SATISFACTORY REVERBERATION TIME IN DIFFERENT ROOMS

Good hearing conditions depend upon what Sabine called the "reverberation time" of the room, that is, the time required after the source of sound has stopped for the sound energy that fills the room to die away to one-millionth of its original intensity. This time of decay varies directly as the volume in cubic feet and inversely as the total absorbing power of the surfaces exposed to sound in the room. The absorbing power of a surface is the product of the area and the sound absorption coefficient of the material. The total absorbing power is the sum of these products for all exposed surfaces in the room. Thus the reverberation time, T, of any proposed room can be calculated by Sabine's reverberation equation:

$$T = \frac{0.05\ V}{a} \quad \ldots\ldots\ldots [1]$$

in which V equals the volume in cubic feet and a equals the total absorbing power in units of square feet.

By making this calculation for rooms that are acoustically good, values for the reverberation time that rooms should have in order to be acoustically satisfactory have been established. These are shown in Fig. 1. In current practice a room is treated, when necessary, by attaching to its walls or ceiling the proper area of some one of the numerous types of commercial sound absorbents now on the market. Among these absorbents are highly porous tile, fabricated from mineral, vegetable, or hair fiber; granulated pumice or slag pressed with a low percentage of binder to permit of intergranular interstices in which the energy of sound waves is dissipated; and one of the various sound-absorbing plaster materials now available.

The use of steel and concrete framing in construction and of electrical sound-amplifying equipment make it practicable to construct rooms of much greater volume than was possible thirty years ago. Accordingly, the necessity for increased use of artificial absorbents in the theaters and concert halls of the future seems a perfectly safe prediction. The future of this field lies in the development of normal materials of only moderate absorbing efficiency that can be applied easily and naturally over large areas and at a cost so low as to make their use in every room intended for audience purposes a matter of course.

In rooms with highly reflective walls and ceilings, every sound that is produced is prolonged by being reflected back and forth many times. As a result of this cumulative action, the noise caused by the repeated operation of a machine may be several times louder than that produced at each operation. Quite apart from consideration of the comfort of office workers, the known increase in efficiency resulting from noise reduction seems to be a sufficient basis for predicting that, in the office buildings of the future, the use of sound-absorbent ceilings will be taken for granted.

ELIMINATING OUTSIDE SOURCES OF NOISE

Protecting the occupants of a room from noises originating outside the building or from noises created elsewhere within the building calls for quantitative data on the various factors that effect the transmission of sound through walls or partitions. Prior to the erection, some 14 years ago, of the sound laboratory at Riverbank, Ill., practically nothing of a scientific nature was known as to just what characteristics were essential to the sound-insulating properties of a partition. Using large-scale methods, tests were made on the reduction of sound in transmission by various types of partition construction. A summary of some of the more important results of this program of research follows, and some of the results are illustrated in Fig. 2.

1. Reduction of sound in transmission through porous, flexible materials, such as felt and fiber board, is an absorptive process, so that the logarithm of the reduction by such materials increases in a straight-line ratio with the increase in thickness.

2. The reduction in transmission of sound by porous materials that are good absorbers and poor reflectors is small in comparison with that by impervious materials which are good reflectors and poor absorbers. Thus the reduction resulting from using 4 in. of hair felt is less than is produced by 1 in. of solid plaster.

3. The transmission of sound through solid impervious partitions results from the forced vibration of such structures under the alternating pressures of sound waves. These vibrations set up sound waves on the farther side of the partition. Sound transmission is therefore a matter of the over-all mass, stiffness, and frictional damping of the structure as a whole.

4. The sound reduction averaged over the whole range of frequencies produced by simple partitions of masonry (plaster, clay and gypsum tile, and brick) is very nearly proportional to the cube of the weight per square foot, regardless of the masonry material of the partition.

5. Sound reduction resulting from double-wall construction is conditioned by the degree to which the two units of such construction are structurally and spatially separated. In case of an otherwise complete structural separation, filling the inter-wall space with fibrous or granular material increases sound transmission. In fact even slight structural tying increases it.

6. A combination of a heavy construction and a light construction elastically coupled is the most effective means of securing high acoustic insulation without excessive weight or thickness.

7. In a broad sense, the mass of a partition plays the predominating role in determining its sound-insulating value. The sound reduction increases with the mass, although variation in stiffness and internal damping may, in cases of marked variation in these properties, mask the effect of mass alone. Sound insulation is a problem of structure rather than of materials.

Obviously, if building in the future is to follow the trend toward lighter construction, the problem of securing adequate sound insulation with such construction is one calling for further research. To secure the maximum sound insulation between apartments, current practice in steel and concrete construction employs floors floated on resilient mounting and ceilings suspended from floor slabs rather than attached directly to them. Walls between adjoining apartments are of heavy tile construction, to which the plaster base is attached by resilient clips.

RELATION OF VENTILATION TO NOISE REDUCTION

Reduction of the volume of sound transmitted into rooms by way of open windows is a problem that has not as yet been adequately solved. Any opening sufficiently large to admit air in any degree will also enable the entrance of sound. Various types of window mufflers designed to lessen sound by the use of absorbent materials acting as sound baffles have been devised, but the best of these are only moderately successful. Experience shows that people generally will prefer to tolerate the evil of noise rather than forego the doubtful blessing of questionably fresh air from out-of-doors. The advent of the

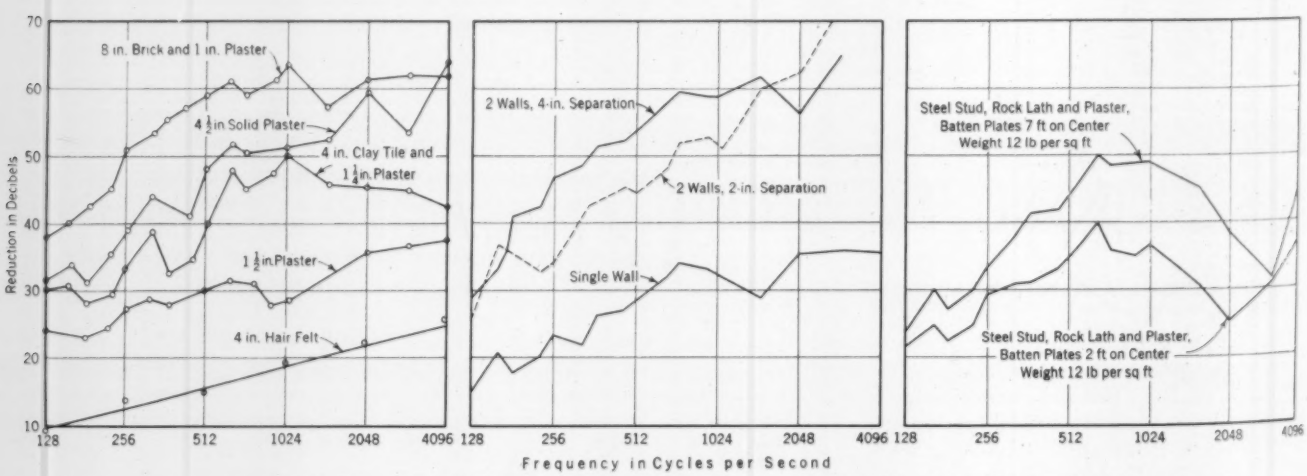

FIG. 2. EFFECT OF CONSTRUCTION ON NOISE TRANSMISSION THROUGH PARTITIONS
(a) Various Materials Have Different Effects. (b) Increasing Air Space in Double Partitions Increases Sound Insulation (c) Increasing Structural Tying Decreases Insulation.

air-conditioned building will bring with it a solution of this problem. With properly designed double windows, always kept closed, an entirely sufficient degree of sound insulation can be secured.

OPPORTUNITIES FOR RESEARCH AND INVENTION

No doubt it will be apparent from the foregoing that the problems of sound control in buildings of the future are not essentially different from those of the present and that their solution will be along existing lines of procedure. The increasing trend away from all stuffiness in room furnishings and the greater severity of architectural treatment in better homes increase the necessity for walls and ceilings that are more absorbent than are hard, non-porous plaster surfaces. The sense of quiet that one gets in heavily carpeted living rooms with fabric draperies and heavily upholstered furniture, can easily be duplicated in an ultra-modern room severely furnished and decorated but equipped with absorbent walls and ceiling.

In sound insulation, relatively little has been done in devising light wall and floor construction of high insulating value but without excessive weight. Research and invention along this line should yield profitable results whatever direction the course of future construction may take. To the pioneer in the new era of building construction it may well be said: Do not neglect the necessity for sound control.

Municipal Facilities for Public Health

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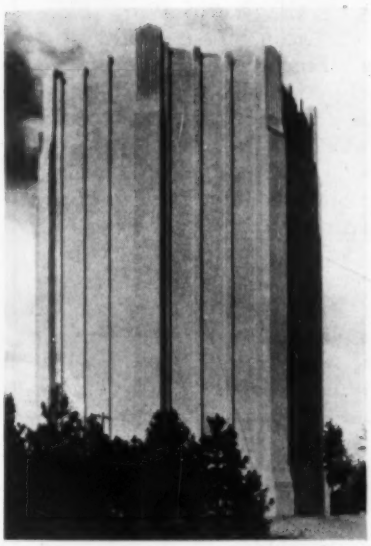

MODERN WATER TOWER, SPOKANE, WASH.
Having a Capacity of 1,250,000 Gal

INCREASED construction facilities and improved construction technique have provided the designer of municipal facilities relating to public health—water works, sewerage systems, and refuse disposal works—with tools that have advanced the art on a practical basis. This is particularly true if construction is held to include the manufacture of materials used in municipal facilities, such as cast-iron pipe, pumping engines, elevated tanks, sewer pipe, equipment for sewage treatment works, and the many kinds of machines used in actual construction in the field.

Advances in the field of construction during the century have resulted from accumulated experience, the availability of larger and more durable materials, and vastly improved field equipment, such as pumps, trenching machines, trucks, steam shovels, compressed air equipment, and pile drivers. The electrification of many construction plants has also promoted progress.

CHANGES IN ONE HUNDRED YEARS

One illustration of the change due to advances in manufacturing is the substitution of pressure conduits of steel and reinforced concrete for gravity masonry aqueducts to conduct water from distant sources. The production and distribution of compressed air have permitted faster and safer tunnel and subaqueous construction at depths up to 100 ft, as compared to 30 ft in the early part of the century. The development of the gas engine and its adaptation to many field purposes have led to greater economy of construction. This engine has also been utilized for motor vehicles of large capacity (25 yd) used to collect refuse. It is of interest to compare these machines with the 4 or 5-cu yd horse-drawn units of yesterday.

In 1833 there were about 40 water works in the United States. Now there are probably over 10,000. A hundred years ago there were no sewerage systems, the first ones being built in Brooklyn and Chicago just prior to 1860. Now practically every community with a water supply has a sewerage system also. A century ago street cleaning and the disposal of refuse were left to the individual and to the scavenging hogs and geese that roamed the streets. Most of the refuse was dumped in streets, alleys, and vacant lots. Now no urban community is without some system of public street cleaning and refuse disposal. The mere construction of this vast number of municipal facilities has provided a wealth of building experience which has benefited succeeding construction projects. In 1830 only a relatively small percentage of the population—possibly 20 per cent, or 2,500,000—was urban. By 1930 municipal facilities had been provided for an urban population of some 60,000,000 people living in cities of over 8,000.

In the earlier days of this construction program, trenches for water pipes and sewers were dug by hand, with staging for deeper cuts. Later bucket machines were introduced and then trenching machines, steam shovels, and drag-line excavators. In this period hand drilling for rock excavation has been replaced by compressed air drills, first of the tripod type and later of the hammer type. Hand-operated diaphragm pumps have been supplemented by gasoline engines and motor-driven units.

In making concrete, hand turning has been supplanted by machine mixing. This and other developments in cement and concrete have resulted in the use of reinforced concrete in many projects where heavy masonry was formerly employed. Movable and collapsible steel forms are now available to supplement those of wood built in the field. These improved and enlarged facilities have permitted a needed increase in the extent and magnitude of municipal facilities, with a concurrent increase in wages for labor.

The construction of municipal facilities depends in

large measure on the efficient use of the available means for handling earth and rock excavation, water, and the various materials which, when put together, form the completed project. A measure of the advance in this efficiency may be found by comparing the relative cost of these municipal facilities and the fluctuating cost of living during the century. However, the public works built to meet the greatly enlarged demands of the rapidly growing municipalities present an even more adequate measure of this advance.

In Fig. 1 are shown indices of wholesale prices from the statistics of the U.S. Bureau of Labor; of wages from the *Monthly Labor Review;* and of prices of cast-iron pipe compiled from several sources. From these indices it appears that during the last one hundred years the relative scale of wages has increased on the whole somewhat faster than have wholesale prices. The indication also is that the wage earner's general standard of living has risen during this "Century of Progress."

I have made a study of the construction costs of a few of the larger municipal facilities, such as reservoirs, lake intake tunnels, and sewers, from about 1850 to date. All these cost records, shown in Fig. 1, have been reduced to a common basis, in which the costs prevailing from 1910 to 1914 correspond to an index of 100. Despite an increase in wages of more than 100 per cent, the trend of unit construction costs appears to have been more or less horizontal during the six decades preceding 1913. The economic disturbances during the World War and the succeeding years have been too severe to permit a judgment as to trends in that period. Prior to the World War, however, improved construction methods in the municipal field appear to have offset the rising wage scale and to have contributed materially to a leveling, instead of an increase, in construction costs.

EFFECT OF IMPROVED METHODS

Some illustrations of the improved methods of manufacturing and erecting several kinds of municipal facilities will be given. Although many others might be included, they would point to the same conclusions.

Manufacturers of cast-iron water pipe appear to have been able to furnish pipes of larger size than has been demanded by designers of water systems. In the first three decades of the nineteenth century, cast-iron pipe was used to a limited extent in water-distribution systems in sizes up to 20 in. and in lengths of 6 and 9 ft. As early as 1820, cast-iron pipe 36 in. in diameter was laid in London, and shortly after the 20-in. size was placed in Philadelphia and St. Louis. Some time during the decade from 1830 to 1840, the vertical or pit casting of water pipe was adopted in England. In 1852 vertical castings of 12-ft water pipe were made at the Warren Foundry in Phillipsburg, N.J. From then on, improvements have been made in the details of manufacturing cast-iron pipe—including such operations as ramming, core making, and pouring with the bell end down—so that larger sizes can be made with greater efficiency.

About 1900 a revolving pit was developed in Germany, by which pipe in 16-ft lengths could be cast. The process was introduced into this country about 1912. The centrifugal casting of pipes had been tried experimentally prior to 1930, but did not come into use on a large scale until the decade following the World War. Prior to 1915 the largest size of cast-iron pipe needed and made was 60 in. in diameter. Since then, 72-in. and 84-in. sizes have been manufactured and used.

There were practically no elevated steel tanks in water-works service prior to the decade 1880–1890, although steel and wooden tanks supported on masonry columns were built at earlier dates. One of the first elevated steel tanks, with a capacity of some 100,000 gal, was built at Fort Dodge, Iowa, in 1894. An early tank having a capacity of 150,000 gal was constructed at Galion, Ohio, in 1900. During the decade from 1900 to 1910, tank sizes increased up to 500,000 gal. A tank at Louisville, Ky., built in 1905, has a capacity of

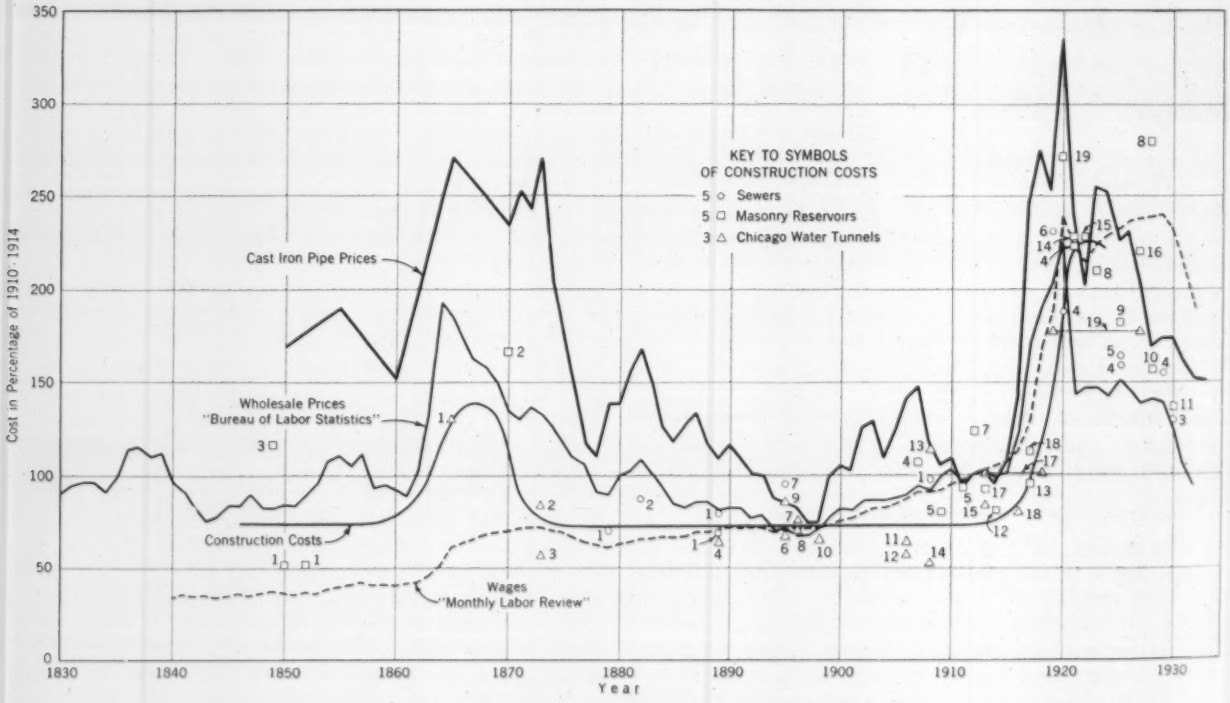

FIG. 1. COST TRENDS DURING THE PAST CENTURY
In the Construction of Municipal Facilities for Public Health

1,000,000 gal. Recently even larger sizes have been furnished. For instance, an elevated tank at Charleston, S.C., and one at Detroit, Mich., have capacities of 2,000,000 gal each.

For many years the method of sinking various types of wells has not changed except as heavier power-driven equipment, sturdier casing pipe, and improved joints have permitted the rapid construction of larger and deeper wells. A description of sinking a well by hand appears in Vol. 46 of *Engineering* for the year 1888. This was a petroleum well in Roumania dug to a depth of 600 ft. It was in effect a shaft 4 ft in diameter, dug by the miner with pick, shovel, and crowbar. The excavated material and the miner himself were hauled up and down by a primitive winch. The shaft was ventilated by a hand-operated fan, but the air supply was so limited that at depths of over 300 ft the miner could work only three or four hours a day. The average rate of excavation was one foot per working day.

The development of concrete, and especially of reinforced concrete, caused a marked change in the construction of many municipal facilities. Perhaps the most notable advance in concrete structures has been field control by use of the water-cement ratio. Ten or a dozen years ago field concrete had a compressive strength of not much over 2,000 lb per sq in. Now it is entirely feasible to make concrete in the field, under proper control, that will have a compressive strength approaching 4,000 lb per sq in.

The construction of municipal facilities has been very much improved and extended with the advance in the application of compressed air to construction work—in particular to the development of portable compressors, air-driven drills and spades, air transportation of concrete, improved ventilation of tunnels, and similar items. Increased progress has resulted from this development in construction equipment.

SUMMARY

Construction is an administrative endeavor that makes use of labor, materials, and equipment for the creation of completed projects. Thus changes and advances in these components constitute a yardstick of the progress made during the past one hundred years. Accumulated experience and improved materials and equipment have been factors of major importance, by means of which constructors have met the demand for vastly increased municipal facilities. At the same time, living standards have risen with but little if any increase in unit construction costs.

Water Transportation During the Century

By J. HOWLAND GARDNER

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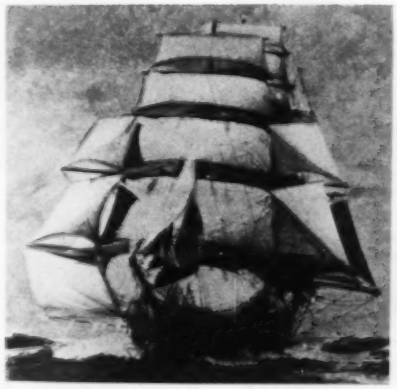


CLIPPER SHIP "LIGHTNING" (1853)

MORE real progress in transportation has taken place during the past century than in the thousands of years that preceded this comparatively short span of time. Transportation is one of the greatest factors, if not the greatest, in our political, social, and economic life. Even the frontiers of civilization are limited by transportation facilities. Our own country gives the best illustration of this. The original 13 states consisted of a strip along the Atlantic seaboard, where bays and inlets and a few navigable rivers leading to the interior afforded comparatively quick and dependable means of communication. In 1807 Fulton's *Clermont* made her first trip to Albany. Fifteen years later there were over 200 steamboats operating on the Ohio and Mississippi Rivers, and the frontier had moved inland to these limits.

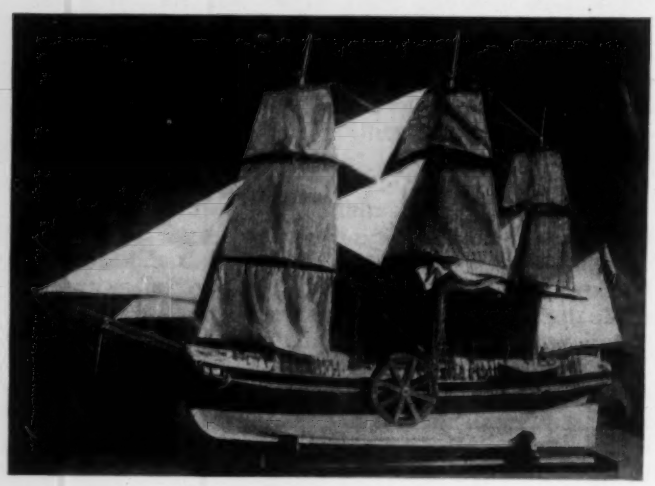
Now turn back a century to the year 1833. At that time transportation by land was over narrow Indian trails or at best over deeply rutted roads. A few small paddle-wheel steamers were doing their best to facilitate the movement of freight and passengers on inland waters. On the sea the United States was beginning to show the world her superiority in ship construction and seamanship. The War of 1812 saw her wrest from England the proud title of "Mistress of the Seas."

In January 1845, Smith and Dimon launched the *Rainbow*, designed by John Willis Griffiths—the first "Yankee clipper." This ship was such a radical departure in design that most people predicted it would be a failure. Even the press announced on the morning set for the launching that a dreamer's rainbow would be lying at the bottom of the East River five minutes after the ship left the ways. The Nation little realized that it was witnessing the birth of a type of ship destined to revolutionize naval architecture and carry its flag to the farthest corners of the earth. The *Rainbow's* first voyage netted her owners 200 per cent more than her original cost. She was acknowledged by all to be the fastest vessel afloat. On her second voyage to China she was thought lost until she herself brought back the first news of her arrival at Canton.

Griffiths next designed the *Sea Witch*, which sailed from New York on December 23, 1846, the tallest ship afloat. She reached China in 104 days and returned in 81, and the next year in 78 days and again in 77—the latter still an unbeaten sailing record for this run. Griffiths' designs were adopted by the great merchants of Boston, Philadelphia, and Baltimore, and copied in England and other maritime nations.

Then came the discovery of gold in California, and the Yankee clipper came into its own, not only at home, but in foreign trade. The fast American clipper ships were loading under charter from the Far East to England at $40 per ton of 40 cu ft, with a bonus of from $4 to $6 a ton additional, while the slower English ships were glad to get $13 to $14 per ton of 50 cu ft. The running time to San Francisco was ordinarily from six to over seven months. The famous clipper *Sea Witch* cut it to 97 days.

In August 1851, the *Flying Cloud*, built by Donald McKay, Griffiths' most renowned disciple, established a record of 89 days from New York to the Golden Gate around Cape Horn, and this is still unbeaten. On March 1, 1854, his *Lightning* logged better than 18 knots and covered 436 knots in 24 hr, a record never equaled before



MODEL OF "S. S. SAVANNAH" BUILT IN 1813
First Steamship to Cross the Atlantic Ocean

or since by any sailing ship, and not surpassed by an ocean-going steamer for some thirty years.

DEVELOPMENT OF STEAM VESSELS

It was 101 years ago that the first steam vessel arrived in Chicago, carrying supplies for the Black Hawk War. In 1833 there were 11 steamboats operating on the Great Lakes. About ten years later the change from side wheelers to propellers began, and by 1860 there were 118 vessels of the latter type. They averaged, however, less than 500 tons each.

During the Civil War a new type of ship was developed on the Lakes with engines located aft. The outgrowth of this type is the great ore carrier of today. The largest side-wheel steamer in the world, the *Greater Detroit*, designed by the late Frank Kirby in 1923, with a speed of 20 statute miles per hour and accommodations for over 1,500 passengers, also operates on the Great Lakes.

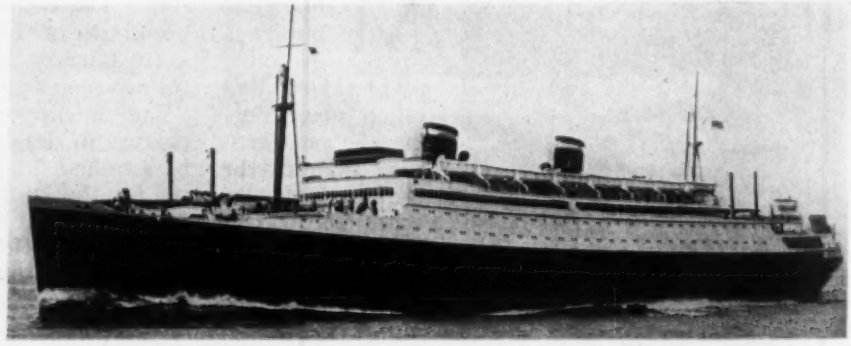
Some 12 years after Fulton's *Clermont* started on her epoch-making trip up the Hudson, the *Savannah*, the first steamship to navigate in deep water, crossed from Savannah, Ga., to England. She was only about 120 ft long and was originally built as a sailing ship. Later she was fitted with a boiler and steam machinery driving side wheels. The wheels were of peculiar design and could be collapsed and taken on deck in bad weather, or when not in use. Her arrival in England caused great consternation, for no one had ever seen or heard of such a ship before. When the black smoke enveloped her masts and sails everything that could float went to the rescue of the supposedly burning ship. Imagine the surprise when she paddled along to her anchorage.

The *Manhattan* and *Washington*, the largest and finest merchant vessels ever built in this country have just been placed in service in the North Atlantic between New York and European ports. They were designed and built by the New York Shipbuilding Company for the United States Lines and are 705 ft long and of a gross tonnage exceeding 24,000. Their geared turbines, operating twin screws, develop 30,000 hp at a steam pressure of 390 lb per sq in and 200 deg super-heat. The three twin-screw geared-turbine Matson Line vessels built at Fore River by the Bethlehem Shipbuilding Corporation, Ltd., and the two turbo-electric-drive Dollar Liners built by the Newport News Shipbuilding and Dry Dock Company are also typical of American practice.

These vessels are among the 42 modern seagoing ships that have been built under the Merchant Marine Act of 1928. These 42 vessels are, ship for ship, the equal in operating efficiency and safety of those constructed anywhere in the world. They not only comply with, but in many respects exceed, the criterion of safety laid down by the International Convention on Safety of Life at Sea in 1929. They constitute a substantial nucleus for an American Merchant Marine in foreign trade and for naval auxiliaries if and when required.

The development of reciprocating machinery with cylindrical boilers reached its height from 1900 to 1905. About this time four great factors entered the marine field: first, the water-tube boiler gave a more efficient method of heat transmission and made possible higher steam pressures; second, the turbine drive was developed by Sir Charles Parsons and Charles G. Curtis; third, the U.S. Navy conducted a series of valuable experiments on the combustion of liquid fluid; and fourth, super-heated steam came increasingly into use.

This year marks the twenty-fifth anniversary of turbo-electric propulsion as applied to marine practice. The first ships in the world to be equipped with a turbo-electric drive were the fire-boats *Graeme Stewart* and *Joseph Medill*, built for the City of Chicago in 1908. These vessels are still in service. The turbo-electric drive has since been installed in 66 vessels aggregating over a million shaft horsepower.



"S. S. MANHATTAN," LAUNCHED IN 1933
The Pride of the American Merchant Marine

Diesel engines are still holding a prominent place in world ship construction. Based on the tonnage of ships built in the United States, however, the progress has not been so rapid. There are at the present time only 84 American seagoing vessels above 2,000 gross tons in which this form of propulsion is used.

In the last century the horsepower of a single vessel has grown from 625 to 200,000 and fuel consumption has fallen from 10 lb of coal per hp-hr to as low as 0.6 lb of oil per hp-hr, with an increase in speed of from 6 to 40 knots. It has indeed been a "Century of Progress."

Turning to the ships themselves, the most important development of the past one hundred years has been the

change from wooden hulls, first to iron, and later, about 1890, to steel. Shipbuilding is and always has been an art, and is continuing in ever increasing perfection. Since the advent of steam propulsion, the design of vessels has gradually become a science. The determination of speed, power, strength, and stability of the vessel and the efficiency of her machinery are now determined and evaluated by trained scientists—the naval architect and the marine engineer.

The determination of power and speed is of prime importance. It is gratifying for Americans to know that some of the most outstanding and valuable contributions to this important division of naval architecture have come from Admiral David W. Taylor of our own navy, who was the designer and for many years the superintendent of the U.S. Naval Experimental Model Basin in Washington. There the speed and power of proposed vessels are determined by towed and self-propelled models, with an accuracy undreamed of in earlier days.

The early iron vessels naturally followed, more or less closely, the structural arrangements of their wooden predecessors. However, it soon was recognized that the riveted and consequently rigid edge and butt connections of the shell plating and decks of the iron ship gave it an enormous advantage in structural strength over the wooden one.

As an illustration of this development, it may be noted that the maximum length of practicable wooden hulls is not much over 300 ft. With steel, the only limit on size, as far as strength of hull is concerned, is the available depth of water. Notwithstanding draft limitations, the size and length of ships has increased steadily. To meet the requirements of the longer and relatively shallower ships, special steels of high tensile strength have come into general use during the past few years, with the result that vessels over 1,000 ft in length are now in course of construction.

RELATION OF MERCHANT MARINE TO SEA POWER

Captain Mahan, the great authority on the influence of sea power, has set up the following equation: Sea power = navy + bases + merchant marine. Let any one of the factors on the right-hand side of this equation be reduced and there follows a reduction in sea power. Carried to its logical conclusion, if naval power with its bases is entirely eliminated, the sea power of a country is measured by the strength of its merchant marine.

The Administration has inaugurated a naval rebuilding program that calls for the construction of 32 ships, at least 17 of which are scheduled to be built in private yards. While this will not itself bring our navy up to treaty strength, it is the first step in the right direction, and puts new life into the shipbuilding and allied industries throughout the entire Nation at a time when this is vitally important. About 85 per cent of the expenditures for naval vessels are for labor.

The American people, through Congress, are demanding the rehabilitation of the American Merchant Marine so that the greater part of the country's goods may be carried in American vessels. Congress has taken a leaf from the history of other nations and has come to the support of American shipping. The continuation of this support assures the success of the venture. The Nation is becoming ship-minded. The pioneer spirit of the days of the clipper ship is still here, and sails have been set for a new voyage of national prosperity.

The Shore Establishment for the Navy

By R. E. BAKENHUS
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THE growth of the U.S. Navy afloat has paralleled the stupendous development of the country as a whole. It has been accompanied by an even greater rate of growth in the shore establishment, due to the increased dependence of the modern ship on the shore plant. There can be a navy afloat only as it is established and supported by the shore establishment. The naval vessel must replenish its ammunition and renew its guns after use. It must also have contact with the shore for fuel, food, and medical supplies, for care of personnel, repairs to the ship, and other services, or it will soon be at the mercy of the elements or of the enemy. If the fleet is to be effectively supported, the shore establishment must be actuated by the same high standards that prevail in the fleet.

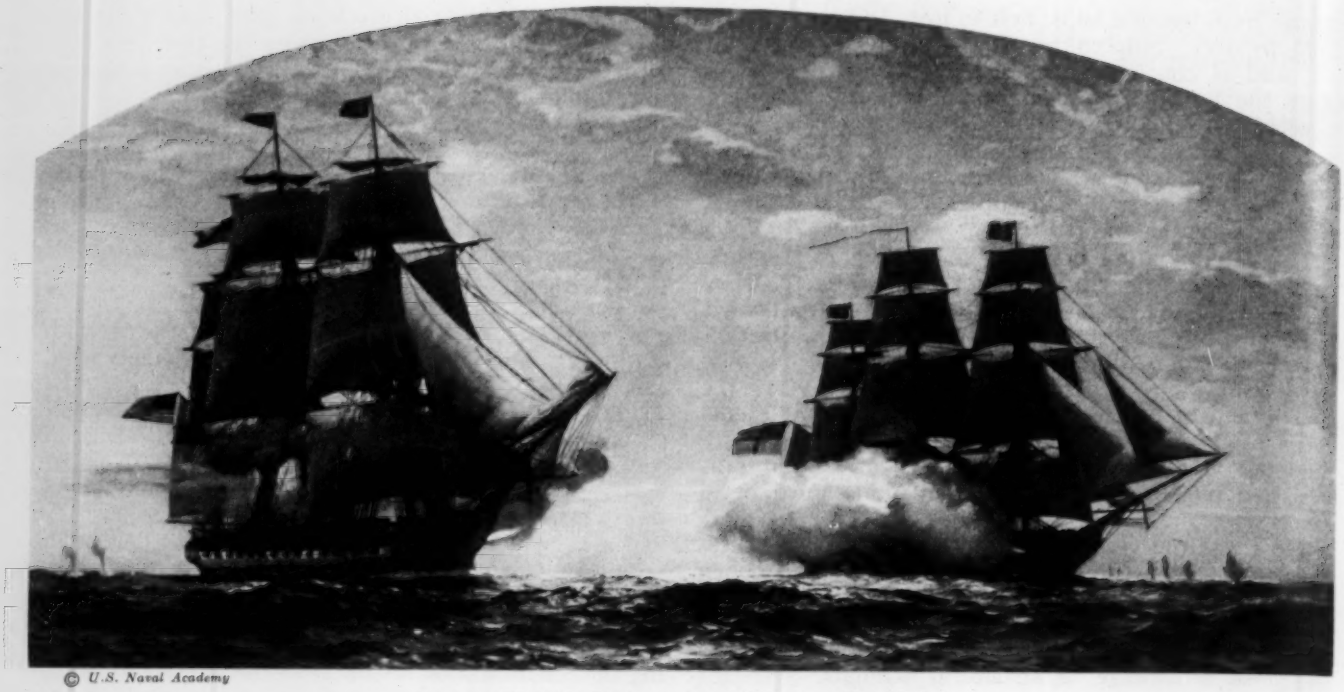
GROWTH OF THE NAVY AFLOAT

In order to understand the growing importance of the shore establishment, a brief comparison of the Navy of 1833 with that of 1933 must be made. One hundred years ago the United States had 12 line battleships with a displacement of about 2,500 tons each, 17 frigates, 15 sloops of war, and 8 schooners of war. The total of 53 fighting ships carried 1,872 guns and had a total displacement of 68,000 tons. These ships, which had beautiful lines, were all constructed of wood and propelled by sail power. However, steam power and armor had come in by the time of the Civil War.

Subsequent to the Civil War, the country lulled itself into a feeling of security and paid little attention to the Navy. The Spanish War brought an expansion of the Navy and extension of the shore establishment. The public demanded naval protection as America once more became world conscious.

There are now 15 battleships in the Treaty Navy, with a total displacement of 455,000 tons and a broadside energy of about 10,000,000 ft-tons in one round of the big guns. The Navy also has 20 heavy cruisers, 15 light cruisers, 4 aircraft carriers, 237 destroyers, 85 submarines, 18 mine layers, 37 mine sweepers, and 65 minor craft, plus 135 auxiliaries. The total number of all ships in 1931 was 631, having a total displacement of over 2,000,000 tons. This includes some ships authorized but not yet built, and some that are nearly obsolete.

There is a tremendous contrast between this new Navy and the old Navy in gun fighting power. While the range of the old-fashioned 32-pounder was approximately 2,400 yd, that of the modern big gun is over 30,000 yd. The muzzle energy of the eight 16-in. modern guns of the battleship *Maryland* is about equal to the estimated



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TYPICAL WOODEN FRIGATES OF A HUNDRED YEARS AGO

The Orignal Painting, "*Constitution* and *Java*," by Charles R. Patterson Hangs in Memorial Hall, U.S. Naval Academy, Annapolis. Reproduced from the *Proceedings* of the U.S. Naval Institute for June 1933

muzzle energy of the entire broadsides of half a dozen navies such as ours of 1833. Torpedoes, mines, depth bombs, and aircraft bombs add to the attack power of the modern Navy. All these attack features demand special developments in the shore establishment. There is a chain of ordnance establishments comprising the smokeless powder factory at Indian Head, Md., mine storage depots, numerous ammunition depots in various parts of the United States and foreign possessions, the tropedo factory at Newport, and the Navy Ordnance Plant at Washington, where guns are manufactured from rough forgings purchased outside.

The late Octave Chanute, Past-President Am. Soc. C.E., had much to do with laying the foundation for practical flying. All actual advance in flying itself has been made in the past 24 years. The World War forced the rapid development of aircraft and it soon became apparent that airplanes, like ships, could not function without ground establishments. Pioneer work was done by the Navy in developing air stations for seaplanes, land planes, and the enormous lighter-than-air craft. At the time of its construction, the hangar at Lakehurst, N.J., contained the greatest cubic content of any building in the world.

The propulsive power of the modern Navy is by steam engine, by steam turbine, by steam-electric drive, and by Diesel and gasoline engines, replacing entirely the sail power of one hundred years ago. This development carries with it a great demand for shore facilities.

Ships communicate with other ships and with the shore by electric signal, by powerful searchlights, by underwater sound apparatus, and by radio, in addition to the visible signaling of the old days. These developments have caused a demand for coastal radio stations.

SHORE FACILITIES FOR BUILDING AND REPAIRING SHIPS

After sufficient depth and area of water have been provided for a navy yard or naval station, the next important requirement is in the field of "water-front engineering," which gives wide scope to the engineer. It includes sea walls, quay walls, piers, wharves, dry docks, marine railways, locks, and shipbuilding ways.

In the old days, sea walls were generally built of granite or other massive stone with a pile or timber crib foundation where necessary. The materials were durable, but there were failures when the depth of water at the face or the surcharge was increased. The more economical modern wall is built of a timber or concrete pile foundation with a sheet-pile cut-off and a relieving platform, which carries a concrete retaining wall. A granite face has been added in recent years to give durability to the concrete. Sea walls and piers of similar construction give the Navy a total of over 40 miles of berthing space.

Thomas Jefferson was vitally interested in the Navy of his day. About 1802, while President of the United States, he obtained the services of Benjamin H. Latrobe, to make a preliminary survey and to estimate the cost of dry docks of a type that Jefferson considered would be of value for repairing and preserving ships that were out of commission. Latrobe considered the Jefferson plan feasible and prepared beautiful and appropriate drawings. He estimated that two such docks would cost about a million dollars. Congress, however, did not approve the project.

It is a striking coincidence that about one hundred years ago—on June 17, 1833—occurred the test of the first dry dock built by the Navy. On that date the old *Delaware* was successfully docked in the new naval dry dock, built of the finest granite, at Gosport, Va. Seven days later the U.S. Frigate *Constitution* was the first vessel to be docked in a similar new dry dock at Charlestown, Mass. Vice-President Martin Van Buren and other officials were present, but President Jackson was prevented by illness from attending.

Over ten years later an even larger granite dry dock was completed at the New York Navy Yard and at that time was the largest in the world. These three dry docks are still in use and promise easily to outlast any subsequently built. They are an enduring monument to their designer and builder, Laommi Baldwin, and the crown-

ing achievement in the career of one of the greatest of American engineers. Plans for these dry docks bear the approval of John Quincy Adams, sixth President of the United States, which shows the importance that was attached to them.

Prior to the completion of these docks, the only method available for examining and repairing the hulls of heavy ships below the water line was that of "heaving down," or beaching the ship at high tide and heaving her over at low tide, an exceedingly slow, expensive, laborious, and dangerous operation, and very unsatisfactory in its results. In a dry dock work might be performed in a few hours, and at trifling expense, which would take weeks by the process then in use.

About 1850 three dry docks of the floating sectional type were built at Portsmouth, N.H.; Philadelphia, Pa.; and Pensacola, Fla., but these are no longer in existence. In subsequent years progress was made in increasing the size and greatly reducing the cost of graving docks.

The Navy has never been able to afford another granite dry dock. Wood as a material for dry-dock construction was superseded by concrete, and all the later graving docks for the Navy have been built of this material, with or without a facing of granite or brick. In the New York Navy Yard actual experience for a period of nearly one hundred years shows the original granite dock to be the most permanent. Next in order comes the wooden dock, and then the concrete.

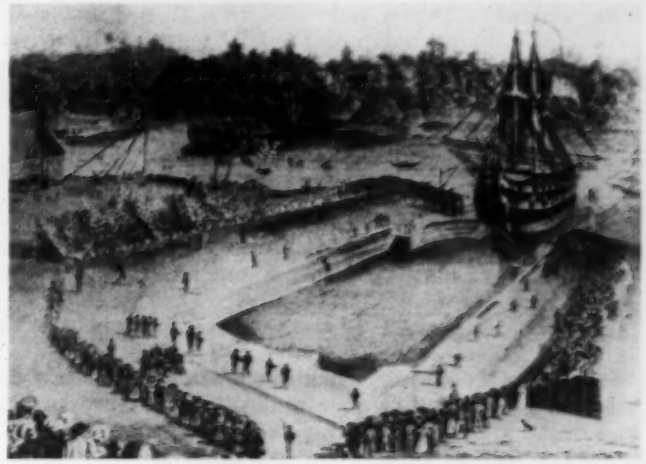
The Navy now has 24 graving docks, including some of the largest and finest in the world. They are located on the east and west coasts and in the Hawaiian Islands. The dock at South Boston could take a ship 1,154 ft long and 119 ft wide, drawing 42 ft of water. So far no ship as large as this has been built. The Navy also owns two steel floating docks, one in New Orleans and one in the Philippine Islands, and a third is under construction. In addition it has 16 marine railways capable of hauling out of the water submarines, destroyers, and other ships with a displacement of from 50 to 2,500 tons.

Ships are built on inclined ways equipped with means for launching them. In the old days the ways were even more rugged than the ships themselves; they were built of granite with firm foundations. Prior to the World War facilities for building battleships were limited to two navy yards and a few privately owned shipyards. During the War there was rapid expansion of these facilities both within and without the Navy. The new installations are equipped with overhead traveling bridge cranes on structural framework covering the entire ways and the assembly field inboard of the ship.

Naval vessels are repaired by Government labor at the navy yards, which have the necessary piers, dry docks, and repair facilities, including foundries for brass, iron, and steel; and shops for patterns, machine tools, electric work, woodwork, forging, structural steel, pipe work, boilers, sheet metal, flags and sails, copper work, boats, and ordnance. When necessary, the Navy is able to manufacture and build any part of a ship or its equipment, from the finest instruments to the heaviest forgings, from the raw materials.

One hundred years ago the first contact of the enlisted man with naval life was on the ship; today it is at the training station. During the World War the four permanent stations with a peace-time capacity of 6,000 men were expanded with marvelous speed into 40 training stations with a capacity of over 200,000 men to supply both the Navy and the Merchant Marine. There are usually six groups of buildings besides the main regimental group. These are for administration, isolation, service, hospitalization, education, and recreation.

The Navy has always had hospitals. The main buildings at Norfolk and New York, which are each over a hundred years old, and that at Boston, which is over 80 years old, are still giving excellent service. The modern permanent hospitals of the Navy are models of their type—plain and modest in design. They were built of good materials at low cost. During the World War the Navy had 27 hospital centers with over 12,000 beds.



THE U.S. "DELAWARE," THE FIRST VESSEL TO ENTER THE GOSPORT (VA.) DRY DOCK, JUNE 17, 1833

Fuel for propulsion is obviously one of the necessities of the modern Navy that was not called for a hundred years ago. Today there are tank farms for the storage of gasoline, fuel oil, Diesel oil, and other fuels, and a few coaling plants. The Navy is charged with the custody of several fuel-oil reservations in the West. It depends also on privately-owned fuel storage.

Before the World War, radio was an undeveloped science. The Navy had much to do with placing it on a practical basis and applying it for use on ships. During the War the Navy built an enormous station in France so that transatlantic messages could be sent without cables, which submarines could cut. This station has eight towers, each 820 ft high—higher than the highest building in New York City at that time.

It may be surprising to note the low cost of the growth of naval power in the United States. In 1830 naval expenditures were 13 per cent of the total expenditure of the Federal Government; in 1930 they were 9 per cent; and in 1932 they were 7 per cent.

The Navy has been dependent on the development of the profession of civil engineering and has appropriated the advances made by civilians in all branches of engineering. As early as March 1802, a member of the congressional Committee on Naval Affairs recommended in connection with the proposed acquisition of Navy yards that suitable civilians be appointed to make plans for improving these yards. The matter lay dormant until Laommi Baldwin was employed by the Navy on dry docks. His assistant at Boston was Alexander Parris, and at Gosport, Va., W. P. S. Sanger. These men, followed by others, carried on public works engineering in the Navy for some 50 years in a civilian capacity. In the earliest days the shore plants of the Navy were under civilian control, and its ships under military command were served by this civilian organization. The control of these plants finally got too far away from

the basic purposes of the Navy, so they were placed under military command, which has continued ever since.

Although it was decided in 1871 to establish a Corps of Civil Engineers as a part of the commissioned naval service, there was a delay of ten years due to opposition within the Navy before commissions were issued.

One of the fields in which great progress has been made during the century is that of naval organization. As the various branches became more clearly defined, and later, when the responsible office of Chief of Naval Operations was established, more and more efforts were made to utilize the complete innate abilities of the various branches of naval personnel, technical and administrative. The resulting improvement in organization has its roots in a broad concept of naval functions, which may be outlined in part by a statement of the following principles:

1. Naval power consists of fully manned fighting ships and aircraft organized into fleets and other units, supported by the Merchant Marine, created and supported by the naval shore establishment, and actuated by the body of national ideals as put into effect by the National Government; and
2. The sole purpose of the shore establishment is to support the fleet.

The Naval War College, which educates officers of both the line and staff, has done much to formulate correct basic principles and to inculcate the personnel with the doctrines necessary to an effective working organization.

In 1900, in consonance with the development of naval organization, the Bureau of Yards and Docks, which prior to that time had been under purely military command, was by law placed under the control of an officer of the Corps of Civil Engineers. The first chief of bureau was a Past-President of the Society, the late Rear-Admiral Mordecai T. Endicott, Civil Engineer Corps, U.S. Navy. He was prominently connected with the early development of the Isthmian Canal. In this service there have also been Rear-Admiral Robert E. Peary, widely known as the discoverer of the North Pole, and Rear-Admiral H. H. Rousseau, a former chief of bureau and later a member of the Isthmian Canal Commission which successfully built the Panama Canal. The great test of the organization, which came during the World War, was met successfully when the Navy accomplished the unheard-of expansion in public works that became necessary during that period.

In transitions from peace to war, immediate demands on the public works organization of the Navy are to be expected. In the normal course of events there must be increased training facilities on shore before vessels can be fully manned; and the decision to construct additional ships must be preceded by the building of ways. In the same way other branches of the shore establishment must be rapidly extended before the full force of naval power at sea can be exerted. It is therefore essential that the Bureau of Yards and Docks and its supporting public works organization in the field be maintained in an efficient and alert condition.

National Defense Facilities on Land

By LYTLE BROWN
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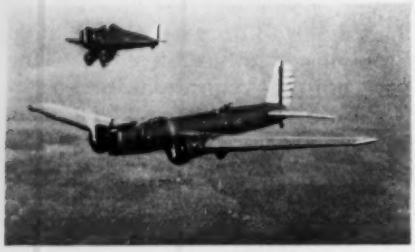


BOMBER ESCORTED BY A PURSUIT PLANE
U.S. Army Air Corps

FOR an understanding of the facilities of national defense, it is desirable to consider the causes and nature of war. War is the most serious venture that a nation can undertake. Ordinarily it comes as a threat against the prosperity of a people or against its security under its government.

At different times during the history of the world, war has had different meanings. Raids, forays, and small expeditions characterized the wars of the Middle Ages. They were wars of sovereigns or rulers, were fought by professional soldiers mainly, and were quite limited in extent and effect. In the days of Genghis Khan and Tamerlane, military chiefs with hordes of followers roamed the earth and put to death thousands, possibly millions, of defenseless human beings in orgies of slaughter, without definite end except possibly plunder.

In the French Revolution the world was introduced to the nation in arms, and Napoleon showed Europe its power. Democracy is really the father of the nation in arms. Prussia learned the lesson from Napoleon and taught it to Germany and to all of Europe, as well as to America. In our Civil War both sides applied the lesson, and in the World War all participants used the same methods. These armies fought generally in accord with the Napoleonic conception of war. They made great concentrations of force and sought battle as the means of ending the conflict.

DEFENSIVE AND OFFENSIVE ACTION

Forces in war may act defensively or offensively. While in some measure the defensive is the strongest form of war, it tends to lower morale, and by surrendering the initiative, gives to the attacker the opportunity for superior concentration of force at the point or points where the decision is sought.

As for weapons, it is evident that they are the same whether for offensive or defensive action, since the attitude is expected to change from time to time, depending on circumstances. Certain facilities—fortification and obstacles—are always used in defense when practicable. Fortification is called permanent when made in time of peace. It has two objects: first, to delay the approach of the enemy until full preparation can be made; and second, to hold the enemy with the minimum force while the maximum force is concentrated elsewhere. Fortification, therefore, is a means for securing economy of forces. When defined in this way it is as important now, if not more so, than it was in days gone by.

Our seacoast fortifications are for the purpose of closing our great ports to hostile warships. If enemy

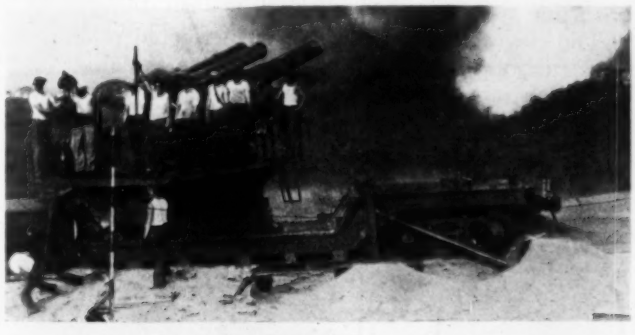
landings are to be made on our shores, they must be made not only in unfavorable places, but at places from which lead poor lines of advance. Further, such fortifications give freedom of action to our Navy in the same way that permanent land forts give freedom of action to the Army. There has been constant change in fortification works as the power of weapons and their number has increased.

WEAPONS OF LAND FORCES

The weapon, given the will and ability to use it, is the prime means of defense. Since as far back as history is recorded, and before, weapons have been of two classes, missiles and hand-to-hand weapons. Of the latter, the pointed thrusting kind has been the most effective. The point is the most difficult to parry, and requires the least force to become deadly. Even today, the hand-to-hand weapon, the bayonet, is morally, if not actually, the decisive weapon. It is really the moral forces that have the greatest effect, as Napoleon said but few seem to realize.

Let us glance in a general way at the weapons of our land forces. The infantry is armed with a high powered magazine rifle of .30 caliber, but the machine gun is the most powerful firing instrument of the infantry. Tanks, or armored cars, are closely connected with the infantry, and are used primarily against machine guns and rifles. The infantry is that arm of the service which can take ground, occupy it, and hold it. The infantry is, as it has always been, the decisive arm of war.

The field artillery is the preeminent arm of fire. It is armed with field guns that are not too heavy to be of great mobility. The target is not visible from the guns, and it is necessary to conceal them as much as possible from all enemy observation. A battery seen by the



RAILROAD-MOUNTED GUN FOR COAST DEFENSE

enemy is generally equivalent to a battery silenced or destroyed.

The cavalry is armed much as is the infantry, except more lightly. Armored cars of high speed operate with the cavalry for reconnaissance and communication purposes. The engineer troops are armed as infantry, but not so elaborately.

Then there is the coast artillery, which is armed with heavy guns for the purpose of defense against warships of all classes. Range finding for seacoast guns is of extreme accuracy, and this, together with a fixed platform from which to fire, gives to such guns an advantage over naval guns that appears insurmountable. In the last war the most powerful ships failed to silence very poor land batteries.

The coast artillery is charged with the mining of our harbors. The very effective system of submarine mines that has been perfected makes it certain that our harbors can be made practically secure against attack by water. The coast artillery is also charged with anti-aircraft defense, in which great advances have been made since the War. About the most difficult of all military targets is a fast-moving plane. To stand a fair chance of making hits, the gun is mechanically trained, the firing data are mechanically calculated and corrected, and the time

THE MODERN INFANTRYMAN AND HIS WEAPONS

One-Pounder (37 mm Cannon); the Tank; the Rifle; the Pistol; the Bayonet; the Hand Grenade; the Trench Mortar; the Automotive Rifle; the Machine Gun; and the Smoke Bomb

between fuse setting and firing is reduced to practically zero.

Since the War, the value of aircraft has been variously estimated, and there are many opinions as to how valuable they really are and where the most valuable. Some go so far as to say that the next war will be fought in the air. That is a lay opinion. It has been answered by a very practical soldier who said, "It may begin in the air but it will end in the mud." However, there is no military man of sound judgment who will deny the great value of aircraft in war. The majority of sound judgments, I believe, are to the effect that aircraft are of the greatest value when used in close conjunction with, and as aids to, troops on the ground. Certainly the absence of an air force will mean disaster to the side that lacks it.

On the subject of air strength the imagination is likely to run wild. It is very expensive, and the economics of peace time are almost sure to greatly restrict the number of planes that will be available for war, even in the case of the most affluent of nations.

There is one weapon developed during the last war that demands passing notice, the so-called poison gas. Will the civil population in cities behind the fighting lines ever be attacked with gas or bombs from the air or from the ground or from the sea? Never, so long as the Army and Navy are worth their salt. It is the fighting men against whom the enemy must direct all their resources or suffer defeat on the battlefield. Indeed the essence of strategy is the use of battle to gain the ends of war.

Gas is more moral than material in its effect. Considering the protection that has been provided, its effect has been greatly exaggerated in the public mind. The artillery is the proper instrument for the use of gas and its kin brother smoke. To a much less extent it may be used from airplanes.

Every military student knows that the value of troops depends largely on two qualities besides the moral power, which is the greatest of the three. These are fire and mobility. The engineer plays a vital part in the mobility of armies. Today we have the greatest means of mobility on a large scale that was ever dreamed of in the past in our ships, railroads, roads, and motor transportation, although on the battlefield itself we must still rely on the legs of men and animals to a certain degree.

An army is wholly immobile without supplies of all essentials. In war use is found for all means of transportation, from the most modern to the most primitive. The most modern machines work out of range of the guns, but as the front is neared, recourse is had to the pick and shovel in the hands of men.

The great work of the engineer in war pertains to mobility, fortification, and shelter. Likewise, he may destroy facilities of this kind to deny them to the enemy. In the future, his work will be more onerous than it has been in the past. Transportation is on a larger scale and loads are heavy. Railroads, roads, and bridges must be maintained under intense traffic and they must be replaced when destroyed by weapons that have grown immensely more powerful with the advent of high explosives in great quantities, long-range rapid-fire guns, and bomb-carrying airplanes. Fortifications require less vulnerability and therefore better materials than in the past, as well as a greater skill in meeting a more intricate problem.

Speed must always be the engineer's greatest consideration. The military standard of punctuality is well known. The engineer's standard means more than punctuality; it means time when time is at its greatest premium in the affairs of men. He will have to make bridges grow over night where ordinary facilities and ordinary materials and equipment are lacking. He will have to build and repair all manner of structures without plans and specifications, and there will be no time to wait for bids. He will have to be engineer and contractor rolled into one, and to bear the travails of both. I have no shadow of a doubt that he will meet the emergency, no doubt of his energy, his resourcefulness, or the greatest virtue he will need, his valor.

Modern Methods Used on Reclamation Projects

By ELWOOD MEAD
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STONE SHOVELS USED FOR CANAL EXCAVATION IN PREHISTORIC TIMES

PROGRESS in the construction of reclamation works has been greater in the past century than in all preceding ones, though in many parts of the world there are irrigation works older than historical records. In this century the U.S. Bureau of Reclamation has been a leader in research, in the adoption of new and better methods, and in the erection of safer and more permanent structures.

Early in the sixteenth century, explorers of the arid Southwest found the Indians watering the thirsty soil as their ancestors had done for centuries before them. How they fixed the grades of their ditches is not known but definite evidence of the implements used to excavate them has been found. The chipped cutting edge of flat stones was employed to loosen the earth, which was loaded into baskets or on pieces of cloth and carried out by hand.

Irrigation in this country by men of English speech dates from the settlement of the Salt Lake Valley by the Mormon pioneers in 1847. The field of potatoes planted in June and irrigated from City Creek saved the little colony from starvation.

The first tools used for irrigation work in this country by the white race were the plow, the pick, and the shovel. Just when the drag scraper or slip was first used for canal excavation is not definitely known but it was over fifty years ago. It was about 1880 that a four-horse scraper was perfected in Fresno County, California. The Fresno scraper has been the principal implement used in the construction of nearly 14,000 miles of canals by the Bureau of Reclamation on Federal projects. This scraper is economical when the haul is short. Under favorable conditions canals have been excavated with it at a cost as low as 7 cents per cu yd. To excavate earth and move it a considerable distance at a low cost, the wheel scraper was developed.

When the Reclamation Bureau was formed and started to build large canals through difficult country, the need of equipment more efficient than men and mules was apparent to all. The steam shovel was first used on railroad construction about 1834, and it had been improved and perfected long before the passage of the Reclamation Act in 1902. The following year the first canal to be built by the Bureau of Reclamation, on the Newlands Project in Nevada, was excavated with five steam shovels.

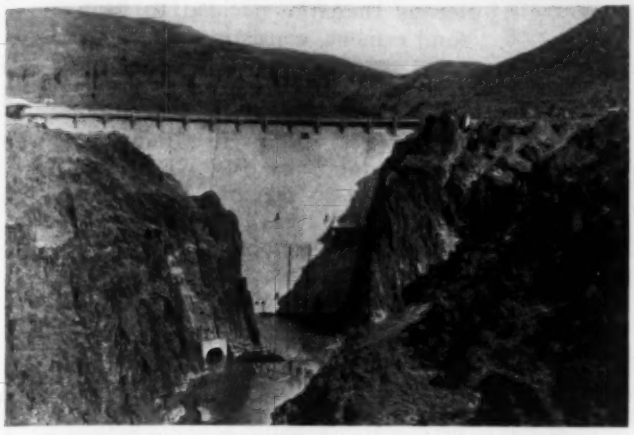
The elevating grader had been perfected prior to the construction of the Chicago drainage canal in 1894, on which it was employed. It has been used since to a limited extent in the construction of canals, particularly where it is possible to follow a grade contour and deposit the excavated material directly in the embankment.

THE FRESNO SCRAPER, THE PRINCIPAL IMPLEMENT USED ON 14,000 MILES OF FEDERAL IRRIGATION CANALS

Drag-line excavators were introduced in 1904 on the construction of the Hennepin Canal in Chicago. This type of machine was adopted by contractors on reclamation projects in 1906. It was made on the job

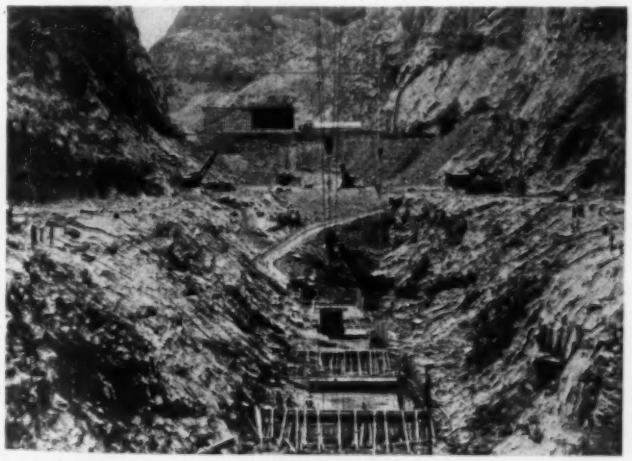
and had all the essential features of the present drag-line. The first caterpillar-traction drag-line was used in 1913 by the bureau on the Lower Yellowstone Project, where it solved the problem of cheap movement of dirt.

In many sections where the Bureau of Reclamation has been operating, the water is heavily impregnated with lime and alkaline salts, which make it unfit for use in steam boilers, and therefore it has been frequently necessary to pipe water for a considerable distance. Gasoline-driven drag-lines have been continually in use since 1917, but during the past few years the Diesel



OWYHEE DAM, OREGON, A 405-FT GRAVITY ARCH
Highest Dam in the World and the First Reclamation Dam to Be Equipped with an Elevator

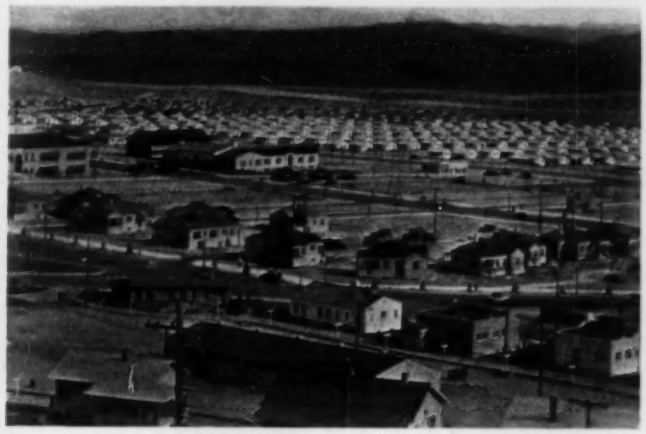
type of engine, on account of its greater fuel economy and efficiency, has been gradually replacing the gasoline engine for this purpose. When construction work on the Sun River Project in Montana was resumed in 1912, electrical energy was available at low rates, and 80 miles of transmission line were built to distribute it to the excavating machines used on the canal system.



POURING THE FIRST CONCRETE AT BOULDER DAM, JUNE 8, 1933
View of the Foundation from Upstream

In 1929 bids were asked on 938 cu yd of canal excavation in Montana, and several bids were submitted at 10 cents per cu yd for Class 1 (earth) excavation. A drainage job in 1932 was let at 5.45 cents per cu yd, which gives a fairly good index to the price at which work of this class may be contracted in the future.

The significant change which Federal reclamation brought into the design of canal structures was the substitution of concrete for wood, although lime mortar and tile had been used by the Indians in Texas and southern California in the seventeenth century. Up to the end of June 1932, a total of 5,052,000 cu yd of



BOULDER CITY, WHICH HAS A POPULATION OF 6,000
Built by the Government at a Cost of $1,700,000

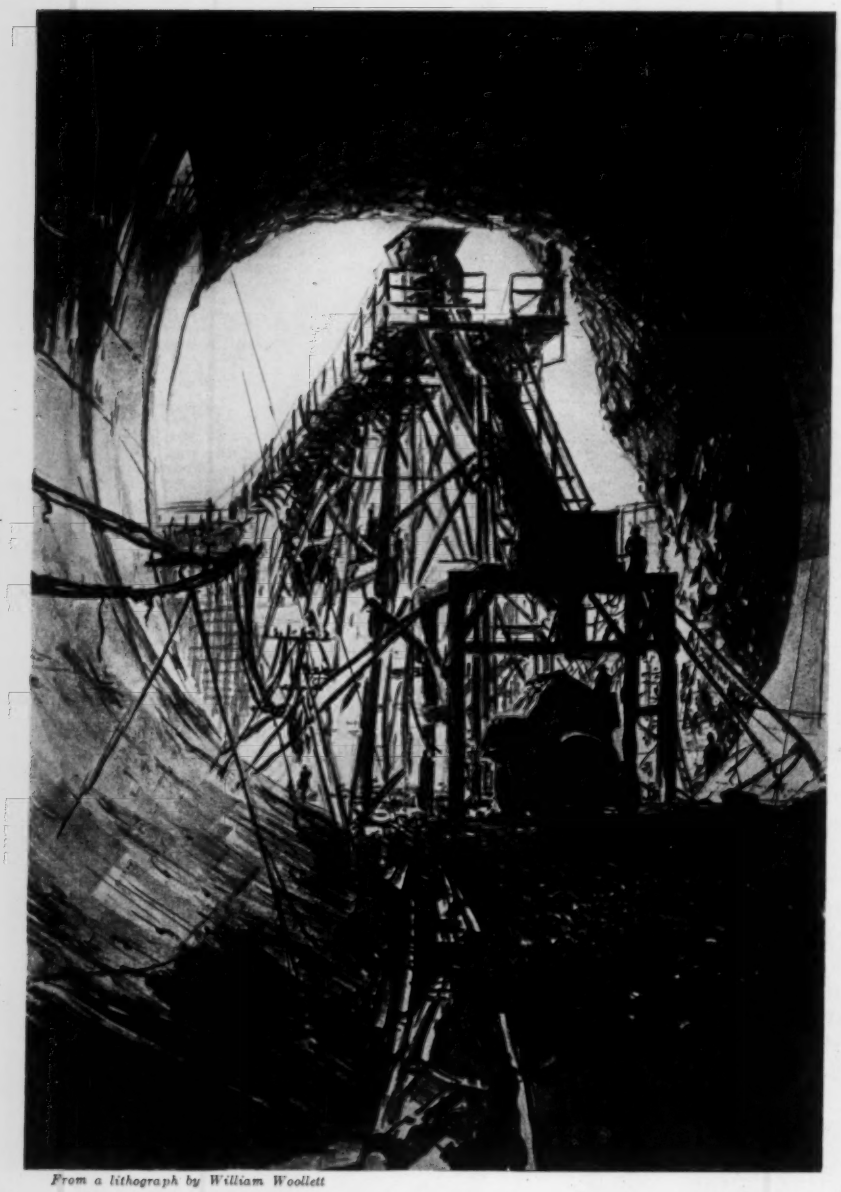
concrete had been placed by the Bureau of Reclamation in more than 100 storage and diversion dams and in more than 64,000 canal structures.

Thirty years ago nothing definite was specified as to the proportions of sand and gravel in concrete except that the engineer was required to make experiments to fix the proportions of cement and aggregates. Hand mixing was then in general use. In 1906 the first specifications appeared fixing the proportions of sand, gravel, and cement and requiring machine mixing. In 1913 a requirement as to tensile strength was inserted in specifications. In 1926 they included a water-cement ratio to give a 3-in. slump; a definite fineness modulus for sand; and a detailed method of grading the aggregate, including cobbles up to 8 in. in size. The Gibson Dam (1926–1930) was the last important structure in which concrete was placed by the use of steel towers and metal spouts.

INCREASING BOLDNESS IN DAM DESIGN

When the Bureau of Reclamation commenced operations in the Salt River Valley, Arizona, in 1903, diversion of water into the canals was usually accomplished by temporary structures of rock and brush that were swept away by periodic floods and then repaired during low-water stages. Since that time the Reclamation Bureau has built 64 storage and 64 diversion dams, and it now has two additional storage dams under construction. It has built almost every conceivable type of dam. The Laguna diversion dam on the Colorado River is of the Indian weir type; there is a concrete weir with rolling steel crest on the Upper Colorado; in Oregon there is the Three-Mile Falls concrete multiple-arch dam; the 222-ft Tieton Dam in Washington is of earth and rock-fill with a concrete core wall extending from bedrock to crest; the Stony Gorge Dam in California is a hollow reinforced-concrete structure of the Ambursen type; and the Owyhee Dam in eastern Oregon, now the highest in the world, is concrete, of the arch-gravity type.

The trial-load method for determining stresses in arch dams, which was developed by engineers of the Bureau of Reclamation several years ago, is now generally accepted as the most satisfactory means of stress analysis for such structures.



From a lithograph by William Woollett

INTERIOR OF A PARTLY LINED DIVERISON TUNNEL AT BOULDER DAM
Bottom Covered by a Roadway for Trucks Carrying Concrete for the Lining

The latest earth-fill dams constructed by the bureau are the two cofferdams on the Boulder Canyon project, which were completed early in 1933. The upper dam is 98 ft high and contains about 500,000 cu yd of material, and the lower one is 66 ft high and has a volume of 293,000 cu yd. Material for the embankments was excavated in borrow pits by $3\frac{1}{2}$-yd electric shovels, loaded into 50-ton side-dump cars, and transported by rail three miles to the canyon. The material was there dumped from a trestle, reloaded into 8 and 10-yd motor trucks by $3\frac{1}{2}$-yd electric shovels, and hauled to the fill. Here it was dumped by the trucks, spread by "bull-dozers," sprinkled, and rolled.

A comparison of the rates of progress in building the Belle Fourche Dam (1906–1910) and the Boulder cofferdams (1932–1933) is interesting. In the working season of 1909, at the Belle Fourche Dam, 529,000 cu yd was placed in about 7 months, and 81,000 in one month. At Boulder Dam 420,000 cu yd was placed in one month. Material for the Belle Fourche Dam was hauled less than one mile, while for the Boulder cofferdams it was hauled three miles and handled twice.

The first masonry dam construction undertaken by the bureau was the 284-ft Roosevelt Dam on the Salt River Project in Arizona, started in 1906. Owing to the inaccessibility of the dam site, the lowest bid for cement, delivered, was $4.89 per bbl. Accordingly the Government built its own mill and manufactured cement at a total cost of $3.14 per bbl, which included plant depreciation.

On the construction of the 306-ft Elephant Butte Dam (1906–1910) portland cement would have cost $2.13 per bbl. It was therefore decided to manufacture sand cement, consisting of one part of cement and one part of sandstone, at a cost of $1.578 per bbl. Sand cement was also used on the 349-ft Arrowrock Dam (1911–1915) in Idaho. It was manufactured by the Government at a cost of $1.35 per bbl, whereas portland cement would have cost $1.80 per bbl.

Because of the great mass of concrete in Boulder Dam (about 3,500,000 yd), extensive research, study, and experimental work on concrete were necessary. The major problem related to heat generation during setting and subsequent contraction in cooling. It was found necessary to divide the mass into blocks and install a system of pipes in the concrete through which to circulate cooling water. A specification has been written for "low-heat" cement. The principal difference between it and the Federal specifications for standard portland cement is the addition of iron oxide.

With the passage of the Boulder Canyon Act on December 21, 1928, and the execution of contracts covering the sale of power, the way was cleared for the construction of this project, of which the 730-ft Boulder Dam in Black Canyon is the principal feature. Both in its design and construction, problems altogether new confronted the bureau. Among the obstacles to be overcome was the fact that this dam had to be built between the sheer walls of a canyon from 1,200 to 1,500 ft high. Four diversion tunnels, each 4,000 ft long and 56 ft in diameter, were built within a 12-month period to divert the river past the excavation. Jumbos drilling 34 holes at a time were used in the tunnels, from which a total of 1,500,000 cu yd of rock was removed.

The outlets to the power plants are plate-steel pipes 30 ft in diameter, having a maximum thickness of $2\frac{3}{4}$ in. The pipes are installed in concrete-lined tunnels, which narrow down to 25 ft in diameter beyond the power penstocks. The latter are 13 ft in diameter. New problems had to be solved in connection with the welding, annealing, transporting, and installing of these pipes, some special sections of which will reach a weight of 150 tons.

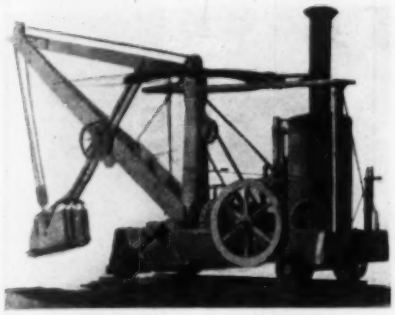
From a financial standpoint, power development is the important feature of the project, since the sale of power will provide revenues sufficient to pay the entire cost of dam and power plant, with interest. In addition it is estimated that after all bills are paid there will be a surplus of $166,000,000 in a 50-year period. The installed capacity of the power plant will be 1,835,000 hp, which is four times the capacity of the plant at

Niagara Falls, and three times the ultimate capacity at Muscle Shoals. The fifteen 115,000-hp turbine units exceed in size the largest that have been manufactured thus far.

In size and in the extent of the physical obstacles to be overcome, the Boulder Canyon Project is the greatest engineering work thus far undertaken in this country. It is being carried out under difficulties rare in engineering annals. Much of the equipment used in its construction has been designed to meet special requirements and, like the different features of this work, has set new high marks as to size. Also, many new records have been made as to speed. The success with which the work is being carried on illustrates the progress that has been made in reclamation methods and design in the past half century.

Evolution of Modern Construction Machinery

By F. CARL RUHLOFF
SALES ENGINEER, BUCYRUS-ERIE COMPANY
SOUTH MILWAUKEE, WIS.



A STEAM SHOVEL OF 1841

AN analysis of any large construction project will indicate that the work involves the excavation, transportation, and disposal of material and then the placing of new material in new forms, requiring the further steps of preparation, transportation, and placement. Although these fundamental operations have not changed during the past one hundred years, the manner of performing them and the various types of equipment used in their performance have been greatly improved.

In November 1874, J. James R. Croes, Past-President Am. Soc. C.E., was awarded the Norman Medal for a very explicit account of the construction of the Croton Dam, published in Vol. 3 (1874) of TRANSACTIONS. This dam, a stone masonry structure with a concrete core, was built in 1866 as a part of the New York water supply system. Mr. Croes mentions the hauling of rock from neighboring hills by means of stone boats drawn by oxen, and states: "When the hills were dry and rocky, the wear on the stone boats was enormous." On modern dams, the contractor is obtaining a guarantee of 12,000 miles per truck tire in quarry service. The wear on the traction element is still of prime importance, but what a great change has taken place in that element!

Trucks require improved roads; therefore machinery is needed at the outset to build the access road to a construction project. Various sizes of excavators, tractors, air compressors, and drills are used for this purpose. The machine has here replaced both man and beast.

QUARRYING ROCK

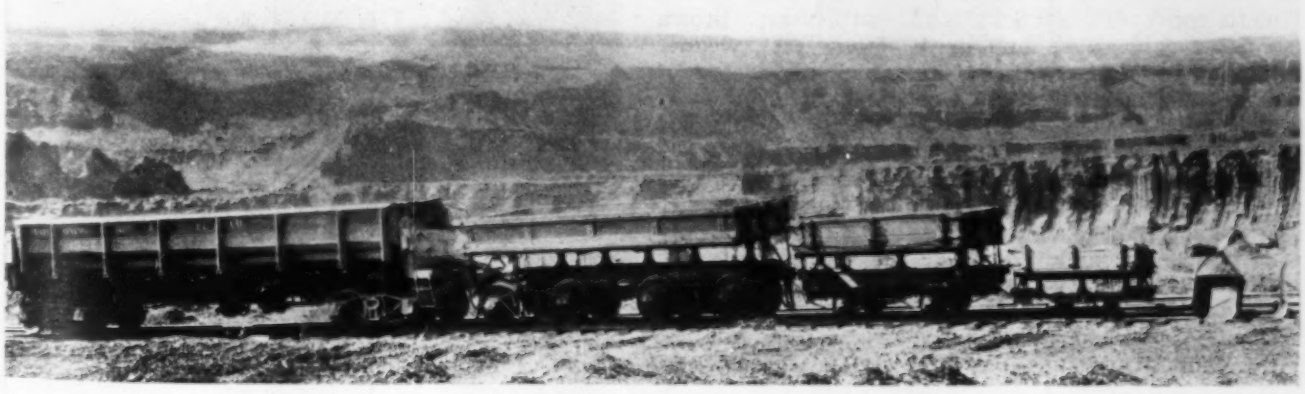
The main power plant on the Croton Dam was a boiler supplying steam to a 15-hp engine, which operated the hoist. This engine was able to hoist material from the pit and at the same time either pump or break stone, but not both.

In the Croton Dam quarry, the 4,000 cu yd of rock for masonry and the 3,400 cu yd of uncut rock were split out with hand drills by the use of plugs and feathers. The 3,000,000 cu yd of rock in the Salt Spring Dam, the 1,117,000 cu yd in San Gabriel Dam No. 2, and the 6,562,000 cu yd in San Gabriel Dam No. 1 could hardly be quarried in this way, even under the impetus of the enthusiasm now prevailing in some quarters for the return to hand labor. In the quarry for the Salt Spring Dam, electric churn drills were used for the 6-in. holes cut to a depth of 150 ft in granite.

Following the drilling operation, that important construction material, dynamite, plays its part. It is not uncommon in present-day construction work to bring down over 300,000 tons of rock with a single blast.

Loading of the rock is the next step, performed by the modern 4-cu yd electric quarry shovel. Dump cars, tractors and trailers, and trucks are used to receive the rock from the 4-cu yd dipper. What a change from the stone boat!

Foundation excavation has also made progress. The

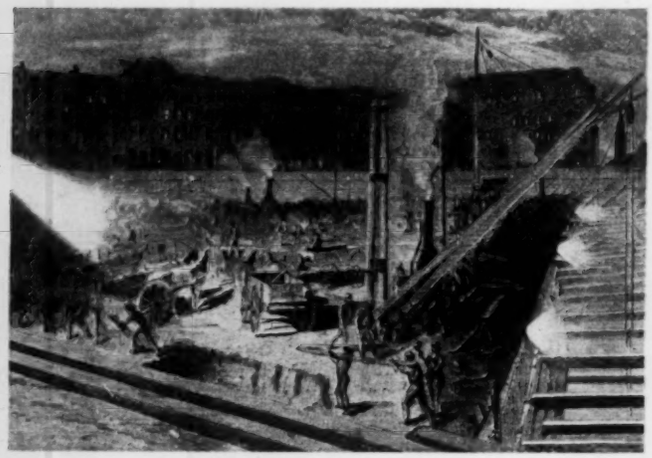


A GRAPHIC ILLUSTRATION OF THE PROGRESS MADE IN METHODS OF TRANSPORTING DIRT
30-Yd Dump Car, 12-Yd Dump Car, 3-Yd Dump Car, 1-Yd Dump Car, Drag Scraper, and No. 2 Shovel

advance is best illustrated by contrasting pictures showing the activities in excavating for the New York Post Office in 1869 and similar work for the buildings of Radio City in 1932.

Regarding the first, Frank Leslie stated:

Eight hundred men and nearly four hundred carts are employed day and night.... As soon as one squad of laborers is exhausted, another is brought on, thus enabling the contractors to carry out their plans without one hour's interruption.



CONSTRUCTION OF NEW YORK POST OFFICE IN 1869
800 Men and 400 Carts Employed Day and Night

It is obvious that the number of men employed on the second project was very limited. The bustle and confusion was replaced by an orderly movement of material.

EQUIPMENT USED ON EARLY PROJECTS

On the French Panama Canal a variety of foreign-built machines were used, among them Belgium locomotives, French elevator-type dredges, Luebecker excavators, and British locomotive cranes. Steam shovels suitable for rock had not been developed, but an American machine, the Osgood shovel, was used and was credited with an output of 2,000 cu yd of earth in 10 hr.

In the building of the Chicago Drainage Canal, which was commenced in 1892, possibly more new construction equipment was developed than on any other project. Here the rock channeler was used; drilling was done both by air and steam drills; blasting methods were improved; and the drag-line had its inception. Conveying the blasted material from the canal prism to the spoil pile presented a problem, which was met in the various stretches of the canal by the use of car hoists; Hulett conveyors, derricks, and cantilevers; Brown cantilever cableways; and in the later years, electric drag-lines handling skips. About the only means of moving material that was not used was the belt conveyor.

APPLICATION OF ELECTRICITY

The construction of the Panama Canal marked the application of electricity to construction machinery and the adoption of a standard of high output, not only for those units employed in the removal of excavated material, but also for those used in the preparation and placement of new material. Up to 1914, about 200,000,000 cu yd of material had been excavated from the prism of the Canal, of which approximately 50 per cent was rock. A 95-ton shovel of 4-cu yd capacity established a record for the Canal of 70,290 cu yd in 26 days. Excavation records made on the Isthmus indicate a splendid transportation system by which cars were kept moving continuously to and from the shovels.

For the Boulder Dam project, no special type of excavating machinery was developed, although the method of operating the excavators was unusual. For example, fully revolving electric shovels with capacities of $2\frac{1}{4}$ to $3\frac{1}{2}$ cu yd were used in the tunnels to load 1,500,000 cu yd of rock into trucks. Also, a special method of drilling was developed, employing a mammoth drill carriage or "jumbo" from which from 24 to 30 drifter drills could make a simultaneous attack on the tunnel face.

RADIO CITY, NEW YORK, UNDER CONSTRUCTION IN 1932
A Highly Mechanized Job

Such equipment units as 150-ton locomotives, 30-ton bottom-dump gravel cars, 30-ton gasoline locomotives, trucks with 7 to 14-cu yd capacity, and 10-ton battery locomotives show the diversity of motive power employed for transportation on the Boulder Dam project.

PROGRESS IN LEVEE BUILDING

Levee building along the Mississippi River, which during the past four years has been a bright spot in construction activity, has covered a period of more than a century. During this time, hand labor with spade and shovel, mules, and scrapers or dump wagons, has given way to steam drag-lines followed by steam tower excavators.

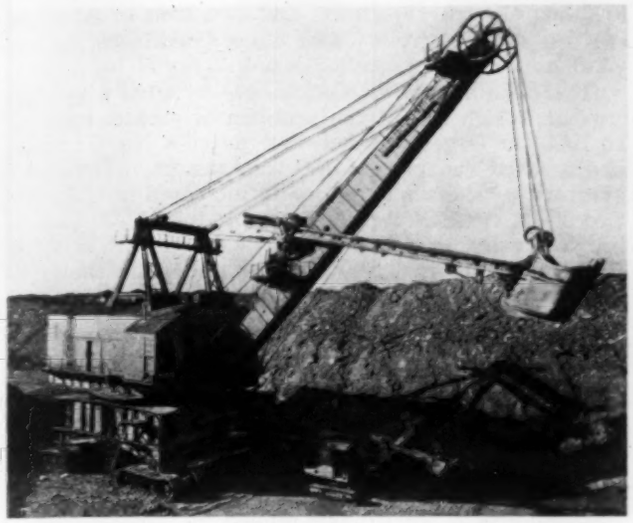
LATE TYPE OF SIDE-HINGED DOUBLE-FULCRUM DUMP CARS

The present levee building program brought a variety of new devices to the river. The tractor with various types of trailers, the elevating grader, special Fresno

scrapers, drag-lines loading dump cars pulled by gasoline locomotives, belt conveyors, diesel-electric walking drag-lines, electric tower excavators—all have had their share in the placing of 87,000,000 cu yd in the six months ending December 1932.

CRANES AND DERRICKS

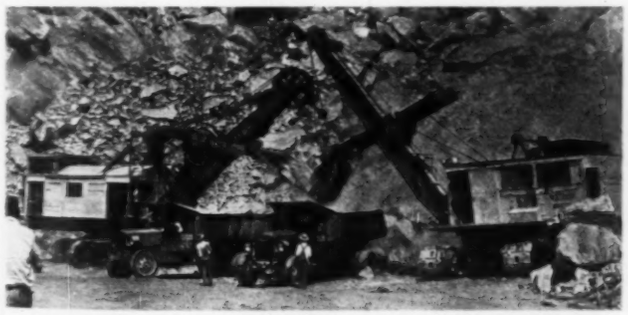
The derrick was and is the contractor's universal tool. On the Croton Dam, one with a 50-ft boom was used for setting the stone and was later replaced by a 30-ft mast with 25-ft booms, as these could be shifted



MODERN CATERPILLAR-MOUNTED, FULLY REVOLVING SHOVELS
A 20-Yd Stripping Shovel and a $^3/_8$-Yd Excavator

and raised more readily. At first the derricks were manipulated by hand, but later 8-hp steam engines operating a single drum were introduced.

The masonry in the East River Bridge was placed by derricks having 35-ft booms, 18-in. iron sheaves, and falls of manila rope. Also, $1^1/_2$-in. wire rope was used on special counterbalanced cranes having a hoisting speed of 60 to 120 fpm. These cranes used engines up to 8



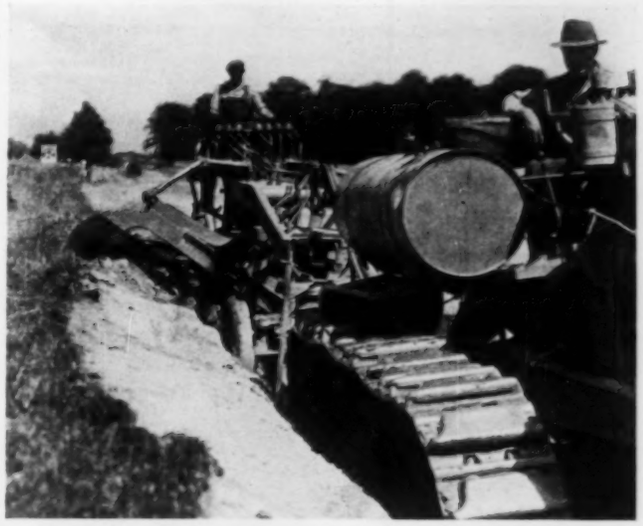
CONSTRUCTION EQUIPMENT AT BOULDER DAM
16-Yd Duralumin Truck Bodies Are Also in Use

by 10 in., operating at a steam pressure of 85 to 100 lb, and having a nominal rating of 25 hp. In the construction of the Empire State Building, 200-hp motor-driven elevator hoists with speeds up to 600 fpm were in service. At Boulder Dam, five 20-ton cableways move material and men across the canyon at a speed of 1,200 fpm.

Fully revolving contractor's shovels up to 4 cu yd in capacity are now being built which can be converted from shovel to crane and drag-line service, thus making a mobile unit available for the contractor.

DRILLS AND AIR COMPRESSORS

A review of rock drills from the early days of hand equipment would cover not only all forms of construction work, but mining as well. It would include Couch's



ROAD GRADER HYDRAULICALLY CONTROLLED AND TRACTOR DRAWN

percussion drill developed in 1849; the power drills built by Brooks, Gates, and Burley in 1866 for the Hoosac Tunnel; the Simon-Ingersoll drill built in 1871; and the various steps from piston type to hammer type. The progress has been not only in the mechanical construction of the drills to increase the hole footage per machine per man, but also in the manner of mounting the drills on special carriages and trucks, so that with a decreased number of men the rock can be attacked at many points.

The first steam shovel was built by W. S. Otis in 1837. Machines of this type were employed on the Western Railroad, the Baltimore and Ohio Railroad, and the Welland Ship Canal. They were also converted for use as dredges on scows. As this machine increased in size and output, it became more compact in form. In 1897 a patent covering a portable revolving shovel was issued to Captain Thew. In 1911, the mobility feature was improved by the adoption of a traction belt of the caterpillar type. Fully revolving caterpillar shovels of $^3/_8$ to 20 cu yd are now in use.

CARS, LOCOMOTIVES, AND TRACTORS

About 1870 the early type of 1-cu yd, man-pushed dump car with portable track was originated in the United States by Petler, whose brother invented the rocker type of dump about 1886. The centrally hinged chain-lock and pole-dump type developed into the double-truck air-dump car, which found its first broad application on the Panama Canal. Cars of 12-cu yd capacity were first ordered for this project in 1904 but the size was soon increased to $18^2/_3$ cu yd. Now these high cars with their locking mechanism are practically obsolete, having been replaced by the side-hinged double-fulcrum type. Naturally, the materials used for dump cars changed from wood to steel following the introduction of steel for other types of railroad cars.

There are now in service electric, gas, and Diesel-powered load-carrying locomotives combining the loco-

motive with the dump car in a single unit to provide increased tractive effort when pulling loads in mine and quarry. No doubt these will soon be adapted to construction work.

The wheeled tractor dates back to 1870, when it was introduced in this country from England. In an endeavor to develop a machine for cross-country use on soft ground, wheels up to 8 ft in diameter and 18 in. in

BUILDING THE ACCESS ROAD TO SAN GABRIEL DAM NO. 2, CALIFORNIA

width were built. The endless-chain platform type, introduced in 1904, demonstrated that the resistance of a track belt was practically constant, whereas the pull required for wheels varied with the character of the ground. In 1905, the change from steam to gasoline engine occurred. The gasoline "caterpillar" tractor was first used on the Los Angeles Aqueduct leading from Owens Valley, where a fleet pulled heavy material across the Mojave Desert and up the mountain sides. The caterpillar tractor has grown in power and seems continually able to pull more and more attachments over the job, so that now it has been termed the "most ubiquitous" piece of equipment.

At the beginning of the twentieth century, various types of power-driven road-building units were introduced, having either an independent or a ground-driven drive, and finally a power take-off from tractor units. The development of this equipment was extremely rapid and covered a very broad field. An indication of its mechanical progress is shown by the variety of controls found on these units, both of the mechanical and hydraulic types.

EQUIPMENT FOR THE CRUSHING OF STONE

The first stone crusher was identified with construction work in 1852, when Eli Whitney Blake, who was a member of a committee appointed to supervise the resurfacing of a street with crushed stone, invented a machine to supplant hand labor in the preparation of the stone. Until the last quarter of the nineteenth century, most stone crushers were of the movable-jaw type, either of the Blake type, with the jaw pivoted at the top, or of the Dodge type, with the jaw pivoted at the bottom.

A Blake machine with a 16-in. jaw was used to crush stone for the Croton Dam in 1866. It was driven by a 15-hp steam engine. According to Mr. Croes, when operated at top speed it required two men to supply the stone, one man to keep the grizzly clear and to help in filling the wheelbarrows, and two men to wheel the crushed stone away. Under these conditions, 54.4 cu yd of stone could be crushed in one day of 10 hr.

In 1880, Philetus W. Gates, Sr., invented a gyratory crusher, which solved the problem of greater capacity. In 1900 the largest crusher, designated a No. 8 breaker, had a rated capacity of 150 tons per hr. The size of gyratory crushers was gradually increased until in 1925 two 60-in. crushers were able to produce 1,200 tons per hr. The range in output from 54.4 cu yd in 10 hr by the Blake machine to 1,200 tons in one hour shows the strides that have been made.

PREPARING AGGREGATES AND MIXING CONCRETE

Records for the Croton Dam mention "the most successful sand-washing method, consisting of spreading the sand in a layer of about 3 in. in depth in the bottom of a shallow box 6 ft by 12 ft, slightly inclined and playing upon it with a hose from a force-pump." For the Boulder Dam the limitation of silt to 0.1 to 0.2 per cent requires a much more refined method of washing. The process includes the clarifying of the Colorado River water in batteries of filters before it is used in an elaborate washing plant.

When building the Croton Dam in 1867, "the sand and cement for mortar were mixed on the bank and sent into the pit by a chute to the mixing board." Mr. Croes would be startled by the operations at the Pine Canyon Dam, where dry cement is not only being transported a distance of 730 ft but elevated by means of a special pump at the rate of 150 bbl per hr. This system operates on the principle that finely pulverized materials behave very much like a liquid when they are properly mixed with air.

As an indication of the 1866 method of mixing concrete, Mr. Croes wrote, "standing a barrel with both heads out, on the corner of the platform, filling it with sand which with a twist of the barrel he [the mixer] spread, then opened and emptied a barrel of cement on it.... He then turned the mass over and heaped it in a conical pile...." A day's work for a gang of four "mixers" was from 50 to 60 batches, or about 40 cu yd. It is a long stride from this state of the art to the present method as used on Boulder Dam, involving calibrated weighing of aggregates and automatic timing of mixing. The intermediate steps included the cubical box journaled at diagonally opposite corners and supplied with a door in one side, and the 2-cu yd mixers used at Panama for placing 5,000,000 cu yd of concrete.

Transportation of concrete by belt conveyors, mixing trucks, crane-handled pouring buckets, or pumps, without segregation, illustrates the advancement that has taken place in this special art of material handling.

The various types of construction machinery now in use have all been developed to possess mobility or portability, compactness, speed of operation, and ease of control. Manual labor has been decreased, but power per man has been increased.

Structural Problems and Laboratory Tests

Enlightening Program Arranged by the Structural Division

For the all-day session of the Structural Division of the Society, held jointly with the Applied Mechanics Division of the American Society of Mechanical Engineers, on June 29, 1933, at the Annual Convention in Chicago, a series of six papers, strictly technical in nature, was arranged. Brief abstracts of these papers are printed here. Three of them deal with the theoretical solution of problems regarding the stability of structures, and three with experimental research in this field.

Laboratory Tests of Multiple-Span Reinforced-Concrete Arches

By WILBUR M. WILSON

MEMBER AMERICAN SOCIETY OF CIVIL ENGINEERS
RESEARCH PROFESSOR OF STRUCTURAL ENGINEERING
UNIVERSITY OF ILLINOIS, URBANA

THIS paper contains the report of recent tests on eight three-span reinforced concrete arch bridges on high piers at the University of Illinois, each structure being about 100 ft long and 40 ft high. The investigation has extended over a period of three years.

Each abutment and pier base was supported on scales so that the horizontal and vertical forces produced at the terminals by the loads could be accurately weighed. Also, each terminal could be rotated or moved, either horizontally or vertically, and could be returned to its original position.

The object of the tests of multiple-span arch bridges consisting of piers and arch ribs, but without a deck, was to verify the mathematical analyses and determine whether the errors in the assumptions produced errors in the results. The tests of arches having in addition spandrel columns and a deck were made to determine the load-carrying capacity of the structure. The results appear to justify the following conclusions relative to the behavior of a three-span arch bridge on high piers.

For a Structure Consisting of a Rib Without a Deck:

1. The elastic theory based on the usual assumptions gives values for the moment, thrust, and shear at various sections that agree with the measured values within the tolerance of the tests.
2. In analyzing a multiple-span arch series, the moment of inertia of a section may be computed on the basis that the concrete takes tension.
3. Considerable cracking of the arch rib does not greatly alter the position or magnitude of the thrust.
4. The maximum unit compression due to design load was 13 per cent greater for a three-span series on 20-ft piers than for a single span with fixed ends.

For a Structure Having a Deck:

5. The effect of the deck is to reduce the moment at the springing line, where it is all resisted by the rib, and to increase the moment over the middle of the span, where the deck acts with the rib.
6. A deck without intermediate expansion joints increases the stiffness and the moment-resisting capacity of the central part of the structure. Intermediate expansion joints reduce both of these effects.
7. The movement at each expansion joint due to a change in span was about 0.25 of the change in span.
8. The unit compression due to design load was 17 per cent greater for a three-span structure on 20-ft piers than for a single span with fixed ends.

For All Structures Tested:

9. The concrete in the arch developed approximately the same unit stress as the same concrete in 6 by 12-in. control cylinders.
10. These tests are very reassuring since they show that a reinforced concrete arch bridge is a very strong as well as a beautiful structure.

Rational Design of Steel Columns

By D. H. YOUNG

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SINCE the time of Euler (1759), the resistance and stability of compression members have been controversial subjects. The inherent difficulty with the column is that slight imperfections have a pronounced effect on its behavior. Theories that do not take into account the extent of such imperfections are of little practical value. It is present-day practice to design columns by empirical formulas. Because such formulas are backed by much experience, they generally prove satisfactory. The designer, however, has at his disposal such a variety of formulas that widely different results can be obtained for the same column.

Granting the sufficiency of empirical formulas for columns of usual proportions, it seems desirable to have a theoretical basis for design that will take account of all necessary factors. It is proposed to select the working loads for columns on the basis of the loading that first produces yielding in the extreme fibers. An ideal column is known to become unstable when the load reaches the Euler value, as given by the equation:

$$P_e = \frac{\pi^2 EI}{l^2}$$

Columns, as found in practice, never fulfill the ideal assumptions. Their chief imperfections are initial crookedness, non-central application of the load, and imperfect elasticity. It has been shown that the effect of all imperfections can be well represented by some initial curvature of the axis. The behavior of columns initially curved can be completely accounted for by ordinary analysis.

It is proposed to deal with the fundamental case of a pin-ended column of solid, uniform cross section; to

take an initial shape of the axis in the form of a half sine wave, with a certain deflection, δ, at the center; and then to base the working load on the load that first produces yielding in the extreme fibers. The only factor difficult to decide upon is the value of δ to be assumed. On the basis of available evidence it is recommended to choose δ so that $\frac{\delta}{l} = \frac{1}{400}$. Then,

$$\frac{P}{A} = \frac{\sigma \text{ y.p.}}{1 + \left(\frac{l}{400\,k}\right)\left(\frac{1}{1 - \frac{P}{P_e}}\right)}$$

in which

σ y.p. = yield point stress

k = cross-sectional core radius

P_e = the Euler load

From this equation a curve is plotted which shows values of P/A to produce yielding, against a slenderness ratio of l/r. Such a curve is proposed for the design of pin-ended columns. It is known that various cases of fixed-end conditions and columns of variable cross section can be treated in terms of the fundamental case by the use of a fictitious length. Built-up columns, where lacing bars or battens are used, can also be treated by the use of a fictitious length. Thus the curve recommended can be used for a variety of cases.

Curves were presented on the basis of which it is possible to design columns in rigid frames with a definite factor of safety (against yielding) once the secondary end moments arising from the rigidity of the joints are known.

As soon as a column begins to deflect laterally under load, the cross sections are no longer perpendicular to the load, and shearing forces are introduced. In built-up columns the lacing or battens must be strong enough to resist these shearing forces. Other curves were presented on the basis of which a rational design of the lacing or battens can be made.

Stability of Plate Girder Webs

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ONE problem which cannot be considered as completely settled is that of proportioning plate girders, particularly those of exceptionally large dimensions, for which a large experience is lacking. It is well known that the web, if not sufficiently thick or not satisfactorily stiffened, may buckle sidewise and act as a tie while the stiffeners are working as struts.

Considering the elastic stability of rectangular plates subject to bending or shearing stresses in their plane, the following method is proposed. First determine the thickness of the web required at the middle of the span to prevent buckling. By making the most unfavorable assumptions, the ratio of the depth, h, of the girder to the web thickness, t, may be made equal to 180. By taking into account the vertical stiffeners, a value of 200 and higher can sometimes be safely assumed for this ratio. In large spans horizontal stiffeners are more effective in the central part than vertical stiffeners.

When the thickness of the web has been selected, the spacing of the stiffeners must be determined so as to enable the web to transmit shearing stresses without buckling. For this purpose curves are presented. A factor of safety of 1.5 is recommended. It is shown also that if the value of the ratio is no higher than 85, stiffeners are needed only where concentrated loads are applied.

If the web thickness and the stiffener spacing are chosen so as to satisfy the stability conditions at the middle of the span and at the supports, then, in the case of a girder of constant cross section, sufficient stability will also be obtained at all intermediate cross sections. The proposed method of proportioning plate girders results usually in a somewhat greater thickness for the web and a longer distance between the stiffeners than is given by the specifications of the American Railway Engineering Association.

Stability of Thin Walled Tubes Under Torsion

By L. H. DONNELL

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IN this paper a theoretical solution is developed for the torsion on a round, thin-walled tube at which the walls become unstable. According to the theory, for short and moderately long tubes:

$$A = 4.6 + \sqrt{7.8 + 1.67H^{3/2}} \text{ (clamped edges)} \quad [1]$$

$$= 2.8 + \sqrt{2.6 + 1.40\,H^{3/2}} \text{ (hinged edges)} \quad [2]$$

where $A = (1 - \mu^2)\frac{SL^2}{Et^2}$; $H = \sqrt{1 - \mu^2}\frac{L^2}{td}$; S = critical shear stress; E = Young's modulus; μ = Poisson's ratio; L = length; d = diameter; and t = thickness. It is assumed that end cross sections of the tube remain circular and plane, that "clamped" edges are held perpendicular to these cross sections while "hinged" edges are free to change their angle with them.

Starting with the usual assumptions, the differential equations of equilibrium are derived in a simpler form than has previously been found, it being shown that many commonly considered items can be neglected. The solution obtained is exact for the two extreme cases when the diameter-length ratio is zero and infinite, and is a good approximation for intermediate cases.

The theory is compared with all available experiments, including about fifty new tests made by the author. The experimental failure torque is always smaller than the theoretical buckling torque, averaging about 75 per cent of it, with a minimum of 60 per cent. As the forms of the deflection check closely with those predicted by theory, and the experiments cover a great range of shapes and materials, this discrepancy can reasonably be ascribed largely to initial imperfections in actual tubes.

By multiplying the foregoing expressions for A by 0.75 or 0.60, expressions are obtained for the average and minimum resistance to buckling to be expected from actual tubes.

Split-H End Connections for Wind Girders

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DURING recent years, the wind girders of steel frame buildings have been commonly connected to the columns by short lengths of rolled H and I sections which had previously been cut longitudinally along the center of the web. The flanges of the connectors are riveted to the columns with either a single or a double row of rivets, and the half-webs are riveted to the girders. Connections of this type are desirable because they can be used in any location without restricting the plan or architectural treatment of a building.

There is considerable difference of opinion among designing engineers concerning the structural action of this type of connection. Some of the questions that have been raised are: first, the reliability of the rivets in tension; second, the effectiveness of the outside rivets because of the deformation of the flange of the connection and that of the column to which it is riveted; and third, the rigidity of the connection as compared with other forms.

An investigation was started about two years ago in the Engineering Experiment Station of the University of Illinois to throw some light on these questions. It has progressed as rapidly as available time and funds would permit and, while still incomplete, has produced results that may be of interest to the designers of steel frame buildings.

Each 2- and 4-rivet specimen consisted of the 2 halves of a split H-section 4 in. long with flanges riveted back to back and webs in the same plane. Each 16-rivet specimen consisted of one of the halves of a split H-section 16 in. long riveted to an H-section column, the web of the connection being at right angles to the web of the column. Each specimen had two rivet lines on each side of the web of the connection, there being one rivet on each inner line in the 2-rivet specimens, one rivet on each line in the 4-rivet specimens, and 4 rivets on each line in the 16-rivet specimens.

The tests made indicate that specimens with four rivets were considerably more effective than the same specimens with two rivets if the flanges were $1^5/_8$ in. thick and the rivets were $^7/_8$ in. in diameter. The effectiveness of the four-rivet specimens decreased rapidly as the flange thickness decreased, until for a flange thickness of one inch, the four-rivet specimens were no more effective than the two-rivet specimens.

The large specimens with connections having flanges $1^9/_{16}$ in. thick riveted to column flanges 2.93 in. thick, with 16 one-inch rivets, indicated that connections of these dimensions were little, if any, more effective than an ideal 8-rivet connection in which all rivets are considered equally stressed, as commonly assumed in design.

The large specimens tested represented very favorable conditions for this type of connection. The connection and column each had the thickest flanges available. If the rivets had been smaller the load distribution would probably have been somewhat more favorable.

The actual effectiveness of 8-rivet connections, with 4 rivets in each of 2 rows parallel to the web of the connection, is to be investigated in the near future as a part of this project. Until this phase of the project is completed, the effectiveness of the 16-rivet and 8-rivet connections cannot be compared, but it is evident that calculations which assume that all the rivets in an 8-rivet or 16-rivet connection carry equal parts of the tensile load on the connection are in error.

Wind Pressure on Buildings

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EXPRESSIONS for wind force, W, and wind pressure, p_i, as now used in aerodynamics, are $W = c_w \left(\frac{p v^2}{2}\right) \times A$; and $p_i = \zeta_i \frac{p v^2}{2}$, in which p is the density of the air; p_i, the wind pressure in kilograms per square meter; c_w and ζ_i, numerical factors which are not constant but functions of stream condition; c_w, the coefficient of wind force; and ζ_i, the coefficient of wind pressure. The investigation of wind forces consists in determining the values of the functions c_w and ζ_i (a problem of aerodynamics) and the determination of wind velocity (a problem of aerology).

An analytical solution of these problems does not exist, and to take measurements on existing buildings is difficult. A more feasible method of attack is to use models of buildings in a wind tunnel. Investigations show that the results obtained with models can be applied with sufficient accuracy in the case of such structures as houses, industrial buildings, and bridge trusses. In the case of structures without sharp edges, such as chimneys of circular cross section and cylindrical tanks for gases and liquids, the problem is more complicated, but in these cases also the model tests give important information.

On the basis of careful observations of weather stations made in Central Europe since 1925, a maximum wind velocity of 100 miles per hr was established. A wind of 80 miles per hr occurs often. Except in the lower strata, 30 to 65 ft thick, at the earth's surface, a uniform wind of constant velocity can be assumed with an accuracy sufficient for practical purposes. It is recommended that calculations be made using a velocity of 90 miles per hr. This velocity should be reduced for the lower sheet of air in one or several steps to 80 miles per hr (for windy regions, 100 and 90 miles per hr, respectively). The opinion that at the sea coast the wind may have higher velocities is not supported by aerological observations. In the case of very high structures that can be brought into oscillation by fluctuation of wind velocity, it is necessary to increase the wind-pressure requirement. The recent investigations showed that the dynamic effect of wind pressure is taken care of with sufficient accuracy by increasing the statical wind pressure by 20 to 30 per cent.

Assuming a wind velocity of 90 miles per hr, that is, $\frac{pv^2}{2} = 20.4$ lb per sq ft, it seems satisfactory to assume for slender structures such as chimneys, radio towers, and lighthouses, a wind velocity of 100 miles per hr, that is, $\frac{pv^2}{2} = 25.5$ lb per sq ft. Assuming these velocities, the wind pressures on structures can be calculated without difficulty on the basis of model experiments.

Highway Improvement

How to Keep It Sold to the Public

By EDWARD J. MEHREN

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HIGHWAY transportation in the United States is without leadership, the kind of leadership that the managements of the great American railroad systems provide. It is pointed out by Mr. Mehren that this lack of leadership is wasteful of public funds and hinders the orderly development of highway transportation. Until such leadership is found, it devolves on each state highway department to accept the duty of representing the highway users—which might be thought of as a corporation named "Highways, Inc."—and of reporting to them regularly on the condition and operation of their property and the advantages of expanding its use. In this article, abstracted from the address delivered before the Highway Division of the Society on June 29, 1933, during the Sixty-Third Annual Convention in Chicago, Mr. Mehren makes definite recommendations for such a program and suggests effective ways of conveying the information to the public.

IN an incredibly short period the highway engineers of this country have built a new transportation system. At the time of our entry into the Great War, state highways were not yet out of the dust and the mud. In the 15 years that have elapsed since the War, a total of 373,000 miles of highways in state systems have been improved, of which 116,000 miles have been paved. Over these roads and the secondary systems allied with them travel annually 24,000,000 automobiles, busses, and motor trucks, rolling up the astonishing total of a hundred billion vehicle miles. The railroad system of the United States is nothing to be ashamed of; in fact, it is the largest and most highly perfected in the world. Yet something like seventy years were required to bring it to the state of perfection which highway transportation has attained in less then twenty years of intensive development. By reason of that development, transportation has been brought to the common man, greatly widening his horizon, broadening his sympathies, and breaking down his provincialism.

THE SYSTEM MORE THAN THE ROAD

To regard the highway alone as the basis of this marvelous development would be taking too narrow a view. It is an essential part, but only a part. To make the system effective there must be included the motor vehicles and auxiliary equipment involving an enormous capital outlay. A railroad system, for comparison, does not consist merely of a track or tracks. To be an operating property, it must include locomotives, cars, terminals and warehouses, coaling and watering stations, repair shops, and a dozen additional facilities and accessories.

The same is true of a highway system. Besides the highway itself, or the track, there are vehicles for both passengers and freight, representing an investment of more than five billion dollars, about the same as that represented by railway rolling stock. In addition there are private and public garages by the millions, filling stations, maintenance and repair shops, tire and accessory stores, parking lots, and other physical items and service accessories. It is apparent, therefore, that modern highway transportation consists of an elaborate grouping of facilities and personnel, no element of which can be omitted if the system is to be effective.

Unlike the railroads, the highway transportation system is not under a single ownership and management. In the highway system, however, the public owns, maintains, and operates the track; some 20 millions of citizens and corporations separately and independently own the vehicles; and other millions of individuals operate public garages, filling stations, repair shops, and parking lots. Here is found the anomaly of a great enterprise without a head—a situation detrimental to highway transportation. There has been no balanced development of the system, no consistent policy, no leadership to forestall, during the depression, the inroads on highway revenues or combat unitedly the disruption of roadbuilding programs solidly planned and carried on for years.

LEADERSHIP NEEDED

Why this effectiveness of the railways, contrasted with the ineffectiveness of the highway group? The answer is obvious. The railroads have acted in unison. Those interested in the highways have been headless and disunited. Such lack of leadership is regrettable. It is wasteful of public funds and detrimental to an orderly development of highway transportation.

This experience points to the great need for leadership. But where is it to be found? The answer to that inquiry is not easy to discover. Yet one thing is certain: until the needed leadership is developed, each state highway department can perform some of the tasks that are awaiting attention. State highway departments represent the motorists of the commonwealth. They might be thought of as a corporation, "Highways, Inc." The state highway officials, as the managers of this corporation, have the duty not only of building, financing, maintaining, and operating the highway system, but also:

1. Of reporting regularly to the stockholders on the condition and operation of their property;
2. Of developing customers by demonstrating that it is profitable to use the services offered; and
3. Of showing the stockholders and users the advantages of expanding the property.

Again consider the railroad, whose management reports regularly to stockholders on the condition of the property, on finance, traffic, and needs. It maintains a traffic department which, through advertising and traffic representatives, tries to increase both passenger and freight business. Highway management has the same responsibilities. It must report to its stockholders, the citizens and taxpayers; it must attract users by proving the economy of the service it offers. In so far as it fails to make such reports and to instruct and enthuse motorists, it lays itself open to misunderstanding, unreasoned criticism, and failure in getting the necessary support for adequate extension of the system.

In suggesting that there be regular reports, I do not refer to the annual reports issued both by railroads and highway departments. These are relatively useless in informing and enthusing the multitude. Rather there should be a steady flow of information through newspapers and other channels which, week by week and even day by day, would keep the public well informed. The material must have the quality of "news" and must be suffused with human interest. Only then will it get interested reading and develop a proper understanding of the highway system and its uses.

WHAT SHALL THE PUBLIC BE TOLD?

The problem of deciding what to tell the public can be divided into two parts, one embracing what interests them as stockholders and the other what interests them as users and prospective users. Citizens and taxpayers, as stockholders, want to know the condition of their highway system, of its financing, of its operation. They will be interested in the size of the highway system; in comparisons with railroad systems; in the investment in the state's highways; and in the amount and character of the traffic on different classes of roads.

Except in a few states the data needed to portray properly the use of the highway systems have not been secured. Traffic statistics are lessons in highway economics and are sorely needed if highway systems are to be adequately understood. The facts gathered in economic and traffic surveys in Michigan and several other states, in cooperation with the Bureau of Public Roads, indicate the possibilities in this direction. The

RELOCATION NEAR WIND GAP, PA.
A Dangerous Curve and an Underpass Eliminated

Michigan survey shows that the state highway system, 9 per cent of the total mileage in that state, bears 66 per cent of all the rural travel; that the county systems, 20 per cent of the total, carry 24 per cent of the traffic; and that the township roads, 71 per cent of all road mileage, handle only 10 per cent of the traffic flow. These and other findings show definitely that the highway revenues collected by the state should be used largely on the trunk lines.

In Illinois similar figures were secured by a comprehensive traffic survey, and were of immediate use. In that state certain interests were loud in their demand that one-third of the gas-tax revenue be spent on township roads. But facts decided the issue. These interests were shown that the township roads carried only 4.4 per cent of all road and street traffic, and that the municipalities contributed 91.1 per cent of the gas-tax funds. The unfairness of the request was so well demonstrated that many of the proponents of township roads withdrew their demands and joined in advocating a more equitable use of the funds.

Operating details, such as signals of the stop-and-go type, direction signs, facilities for protecting and eliminating crossings with other highways and railroads, offer many opportunities to show how safety is being increased. Maintenance work also is but little understood. The organization and location of maintenance forces, the

WIDENING A 20-FT ROAD TO 40 FT
Waukegan Road South of Techny, Ill.

character of their work, the resulting large returns in effective travel—all give opportunities for emphasizing the highway system as a living, throbbing enterprise, in the cause of which thousands of men daily labor to provide for the comfort and safety of the highway user. Even construction, which appears very prosaic to the engineer, is a fascinating operation to the layman. The nicety and precision of present-day methods, resulting in smooth, safe, and permanent roads, does not need an artist's pen to make it vivid and attractive. The work of the field inspectors in the testing laboratory also furnishes many an interesting tale.

TELLING THE ECOMOMIC FACTS

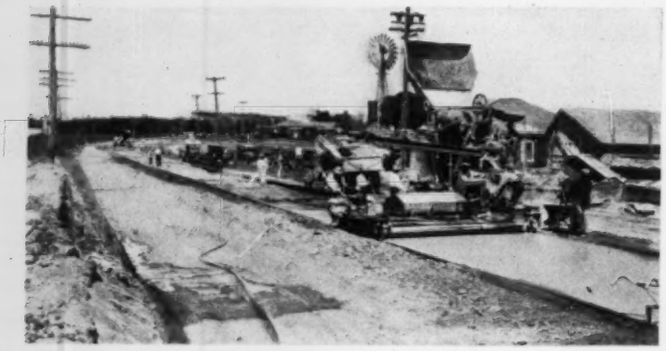
The most important feature of present highway operation is its economics. The day of emotional appeal is past. Hard business facts regarding the profitableness of the highway to the user will dominate highway planning from now on. The data referred to previously in discussing traffic studies are of inestimable value here. It is impossible to lay out a sound highway program unless data are at hand to show whence the revenues are derived. When that is known, the place for their expenditure is automatically determined. Furthermore, many a hard battle between opposing interests—farmers, users of the county road system, motorists who want to dash over a great state system, and city contributors to the gasoline tax—is quickly concluded when such data are available.

It is vitally necessary that the public should understand the distinction between highways and land-service roads—the one an artery of transportation, the other a facility to give access to property. That very distinction shows why the maintenance of the farm road is a proper tax on farm lands and why motor-vehicle fees should be spent on the main highway system.

Finally, there are vast and fascinating opportunities in interpreting to the public the future needs of highways. There is a story that more than a hundred years ago a celebrated English civil engineer discouraged a young man who sought his advice by saying that there was no future in England for the civil engineer because he, the great master, had built all the roads, water supply works, and railroads that England would need. It is apparent that the proponents of gas-tax diversion and highway

holidays take the same view as that celebrated English engineer. They believe that there are enough highways, and that there will be no need to rebuild them according to higher standards.

Again consider the railroads for comparison. America's railroads in 1900 were in splendid condition and had fine equipment. Since then they and their equipment have been entirely rebuilt and doubtless they are on the verge of a new flowering. Three railroads are now talking in terms of light, 100-mile-an-hour trains. The same thing will happen in the case of highways. A generation hence the highway systems of today will be considered as in their infancy.



ROAD CONSTRUCTION PUTS MEN TO WORK ON THE JOB AND IN THE FACTORY

Finishing a 12-Ft Strip of Road from Salinas to Monterey, Calif.

It is the duty of the public-relations specialist of the state highway department to prepare the public for future highway development, explaining the needs, the benefits, and the economies involved. What an opportunity to picture, first in one way and then in another, the ideal highway system—one adequate for the traffic in each area, properly signed and signaled, provided with a grade separation at every crossing, with foot paths, a night lighting system, tree-planted and landscaped roadsides, and comfort stations at intervals! As part of this business of looking forward, emphasis might be placed on the research activities of the highway department, showing how engineers and other officials are projecting their minds into the future and preparing the way for safer, more comfortable, less hampered traffic.

WHAT INTERESTS THE USER

If there is a great wealth of material of interest to the citizen-stockholder, there is quite as much that will appeal to the user and the potential user. Of course the user and stockholder are more or less identical; nevertheless the different types of appeal enable the public-relations representative to present different phases of his subject.

What the user wants to know is what he is getting for his money. To mention some of the points out of which will flow many an item for newspaper and other use, the modern road is an all-weather road, a dustless road, and a safe road, with easy curves and a non-skid surface. It is well marked and equipped with signals, and its hazardous grade crossings have been eliminated. Above all, it is an economical road, on which the motorist saves more in cost of car or truck operation than he pays to the state in license fees and gas taxes. It does not require much imagination to realize the wealth of material that is available for interpretation to the user regarding the advantages of a well-planned, well-built, well-operated highway system.

Once there is an understanding of the material available, the question arises: How is it to be put before the stockholders and customers? An elaborate answer will not be necessary, for the imaginations of road officials will expand a few simple suggestions. The newspapers are a very obvious channel; they like to satisfy their readers, and their readers have an intense interest in highways. Supplied with live, human-interest news from the state highway department, they will eagerly print it. Another obvious outlet is through addresses to chambers of commerce and service clubs. Such bodies are constantly seeking good speakers. The state highway department that does not train some of its force for effective appearance on the platform is doing itself and the public an injustice.

SINGLE-TRACK FEEDER ROAD IN WAYNE COUNTY, OHIO

A further outlet is by way of various highway-user groups. In these the state highway department has strong allies, which are ready to assist it in any legitimate enterprises involving the use and development of the highway system. It is not too much to say that the state highway department which does not organize itself for effective contact with these groups is missing a tremendous opportunity to make itself understood and is neglecting allies of great potential power. Among these groups are: automobile clubs, farm organizations, chain-store associations, retail dry-goods associations, automobile and tire dealers, gasoline and oil interests, commercial trucking interests, and bus operators. These organizations are in a receptive frame of mind. Their success is linked with the highway. They want to understand its problems; they want to help. They are tremendous powers if rightly mobilized.

A GREAT OPPORTUNITY

It is impossible in a brief space to expand this topic fully. It is hoped, however, that the opportunity afforded the state highway department to put the highway system in a right light before the citizens, who are both stockholders and users, has been shown. A commercial organization would not fail to seize it. State organizations may feel less impelled to undertake such work, but if they reflect on the consequences of diverting highway funds in this depression, with the resulting interruption to highway work and disorganization of highway forces, they will be convinced that it cannot be neglected without serious detriment to the highway system, to highway transportation, and to the public.

Some few highway departments have attempted to organize along these lines, but it is safe to say that none has done it adequately or reaped the success that is easily possible. The expense involved is not great.

The Time Element in Highway Traffic Movement

Résumé of Recent Methods of Measuring Both Volume and Speed

STUDIES made on innumerable highways and city streets have shown that the volume of traffic varies consistently according to the hour of the day. It is possible to take half-hour counts, one in the morning and one in the afternoon, which, when added together and multiplied by an experimentally established factor, will give very closely the total traffic for the day. In the first of the two articles that follow, Dr. McClintock elaborates a method of taking short counts and discusses their accuracy.

Highway engineers are coming more and more to realize the value of exact means of determining the amount of delay to vehicular traffic at specific points, such as highway intersections, draw bridges, and grade crossings. By assigning values to the vehicle time involved, the cost of the construction necessary to prevent the delay may be justified. By the same method, different types of traffic control for intersections can be studied, and the limits of traffic density for the efficient operation of any particular type can be determined. The experience of the Division of Highway Transport of the U.S. Government, in developing and using various methods for delay studies, is described by Mr. James in the second of the following articles. Both of these articles are abstracts of the original papers presented before the Highway Division on June 29, 1933, at the Society's Annual Convention in Chicago.

Traffic Volume Studied by Short Time Counts

By MILLER MCCLINTOCK

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THERE are two principal aspects of the time element in highway traffic movement. The first is time in relation to space, or what is commonly called speed; the second is time in relation to volume, or the manner in which volume fluctuates at different times. It is the time-volume aspect of the problem that is here considered.

Studies to determine the volume of traffic were the first, and still remain the most basic, of the investigations undertaken for the analysis of highway traffic characteristics. Typical studies of volume are conducted by recording the total number of traffic units passing a given point during a given period of time. Such a study is usually elaborated to provide for the separate recording of directional movements and frequently for the separate recording of various types of units. A simple statement of the gross results of such an observation for a total time period, such as 12 or 24 hr, would give a very inadequate impression of the actual volume of traffic utilizing the route at any particular moment during the period of the observation. Traffic volume is not constant on any route but fluctuates widely at different times. To measure these fluctuations and to determine the maximum volume it is now common practice to record traffic volume by half-hour periods. When the volumes for these short periods are plotted in sequence for the entire period of the observation, it is possible to draw a curve that will show graphically the time-volume characteristics, or pattern, of the route at the point of observation.

UNIFORMITY OF TIME-VOLUME CURVES OF TRAFFIC

It is a well-known fact that the relative utilization of available routes of travel is governed by the economic and social habits of the population served. The relative volume on alternative routes remains approximately constant, except as it may be modified by radical changes in the physical characteristics of the routes, or by exceptional changes in the economic or social life of the population. The time-volume distribution at a particular point on a particular day approximates that of any other day of like character, and that of any other point on the route in question, or on routes of like character.

In Fig. 1 are shown the distribution curves for five states, based on a large number of highway counts in each state. They all show the same general characteristics: low volume in the period between midnight and six in the morning, a gradual building-up during the day, and a peak at approximately six o'clock in the afternoon. In addition, they show a very close uniformity in the percentage of the total 24-hr flow that is recorded for each hour. This indicates that the same social and economic habits which result in a high degree of uniformity in the time distribution of traffic on local routes, are operative on routes between various sections of the country.

CLOSE CORRELATION FOR CITIES OF SAME SIZE

In Fig. 2 are shown time-volume patterns derived from 24-hr counts specially conducted in 50 American cities by Arthur R. Burnet, Fellow of the Erskine Bureau of Harvard University. They reveal the same general distribution characteristics as the state curves except that there is a definite valley between the peak which occurs just before six o'clock in the afternoon and the high volume of the evening, which reaches a maximum at approximately nine o'clock. The most notable feature of the urban time-volume pattern is the close correlation of the curves for the cities in the various population groups.

The high degree of stability and uniformity of traffic time-volume patterns has some very important implications in connection with methods for the collection

and analysis of traffic volume data. If it is certain that the volume recorded at a particular point for a short period of time bears a relatively fixed relation to the total 24-hr traffic at that point and at other points of like character, accurate data on volume may be computed for periods of 24 hr, of a week, of 30 days, and even of a year, by inexpensive short-count sampling and by the application of predetermined multiplying factors.

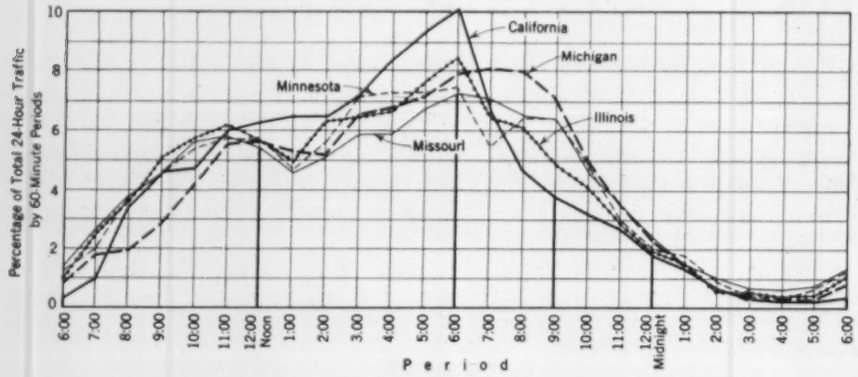
Percentage of Total 24-Hour Traffic by 60-Minute Periods
California
Michigan
Minnesota
Illinois
Missouri
Period
6:00 7:00 8:00 9:00 10:00 11:00 12:00 Noon 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 Midnight 1:00 2:00 3:00 4:00 5:00 6:00

FIG. 1. TIME PATTERNS FOR STATE HIGHWAY TRAFFIC
Drawn from Average Percentages of Summer Traffic Counts Taken by State Highway Departments

In 1931 the Division of Highways of the State of Illinois was confronted by the problem of conducting, as rapidly and inexpensively as possible, a very intensive state-wide traffic census. The authorities in charge of the study approved my suggestion for the use of a short-count program, and the development of the plan was placed in charge of M. J. Fleming, district highway engineer, acting for Frank T. Sheets, M. Am. Soc. C.E., the state highway engineer. Approximately 1,100 counting stations were established throughout the state, covering every highway intersection. These stations were divided into three classes: base stations, at which traffic was recorded for one week day during an 8-hr period, 7 a.m. to 11 a.m. and 2 p.m. to 6 p.m.; key stations, of which there were approximately 126, where traffic was recorded on one week day for a 24-hr period; and master stations, of which there were 43, where traffic was counted continuously through a Friday, Saturday, and Sunday. The key and master stations were located at strategic points characteristic of the traffic of the area covered by the surrounding base stations.

Several assumptions were made, as follows, each of which was subsequently substantiated by other data:

1. The week-day traffic volume, Monday to Friday, inclusive, is practically indentical for each day. This assumption made it possible to determine a factor for the conversion of the 8-hr traffic counts at the base stations into 24-hr totals through the application of a constant multiplying factor derived from an analysis of the Friday counts at master stations. Later counts showed that, taking the Wednesday volume as 100 per cent, the other days of the week were as follows: Monday 99.9, Tuesday 98.3, Thursday 101.7, and Friday 100.1.

2. The ratio of the 8-hr volume (for the identical period used in the counts at base stations) to the 24-hr total at a master station is applicable to all base stations within the area surrounding the master station. This assumption was verified by a calculation of the recorded volume at key stations. The variations between the actual and the computed 24-hr volumes ranged from −27.2 per cent to +23.5 per cent. The normal variation, however, was far less than these extremes; the average was found to be only +0.73 per cent.

3. The traffic volume at base stations varies from day to day in the same proportion as the volume at the master station controlling the area in which they are located. A re-count made six months subsequent to the original study showed that the variation between actual counts and those calculated on the basis of constant multiplying factors, derived from master station ratios, were from −29.1 per cent to +41.3 per cent. These extreme variations were exceptional; the average variation for the entire state was less than 2 per cent. Furthermore, it was discovered that a plus error in the calculated total of a given station on one count was likely to be neutralized by a minus error on the next count.

4. The ratio of volume on Saturday and Sunday to week-day volume is relatively constant at each master station. This assumption was verified by counts made at all master stations subsequent to the original count of August 1931. The re-count data were compared with the computed totals that were based on ratios established in the original counts. The result indicated an average minus error of 6.8 per cent, although there were several excessive plus and minus errors, probably due to the predominately recreational character of the routes covered by these exceptional master stations.

In summary it may be said that the short-count method as applied in the State of Illinois made possible the calculation of traffic volume on all routes in the state highway system for any day in the year, for any week in the year, and for the year as a whole, at a fraction of the cost that would have been required for a one-day full-time count. The errors involved were nominal and in most instances did not exceed the inevitable inaccuracies that would be found in actual counts. A description of the methods used in this study, the graphic and statistical data, and the conclusions reached, have been printed by the State of Illinois under the title, "Report on the Survey of Traffic on Illinois State Highways, August 1931 to Labor Day, 1932."

If short counts composed of a split 8-hr counting period, as used by the State of Illinois, can be converted into accurately computed 24-hr totals, the question naturally arises as to whether a shorter counting period may not afford an adequate basis for equally accurate computation. Assuming a stable time-volume pattern, it follows that any fraction of the total period to be computed will bear a definite relationship to such total period as does any combination of such fractional periods. One must recognize, however, that time-volume patterns are not entirely stable and that deviation from the average in a very short counting period will be reflected in a greater error in the computed total than would be the case if the count covered a longer period.

CONDUCT OF SHORT-COUNT SURVEYS

In 1932 the Erskine Bureau of Harvard University, in connection with its traffic and trade research, undertook a Nation-wide exploration of short counting methods, with a view to determining the minimum periods that would give tolerably accurate results. The time-volume patterns for 50 cities revealed that there is a very substantial stability and uniformity in the patterns throughout the entire 24-hr period, and especially in the hours between nine in the morning and noon, and between

one and four in the afternoon. Each half-hour period within these hours was analyzed separately to establish the normal ratio between its traffic volume and that of the total period of 18 hr between 6 a.m. and 12 midnight.

In practice, the volume recorded for any half-hour between 9 a.m. and noon was added to the total volume recorded for any half-hour between 1 p.m. and 4 p.m. This total was multiplied by the constant factor 32 to obtain a computed 18-hr total. It should be noted that the factor 32 provided for conversion from the shorter to the longer period and likewise for the translation of vehicular units into passenger units, based on a predetermined average load factor of 1.75 persons per vehicle.

The computed totals thus obtained were compared with the actual long counts in each group of cities. The initial analysis made it apparent that the factor 32 was too high, and 27 has now been adopted for the conversion of the combined volumes recorded for morning and afternoon counts of a half hour each. The use of this factor gives a slight minus error, which may confidently be anticipated not to exceed 5 per cent when a group of computations is averaged.

At the present time, organization is definitely under way for the collection and computation of traffic-volume data in 17,000 cities and towns in the United States by the half-hour short-count method and computation of 18-hr totals by applying of a constant national multiplying factor. In each locality a series of actual 18-hr counts will be made to verify the accuracy of the procedure.

While the half-hour short-count method is not recommended for general engineering practice, it should be pointed out that it offers a very economical and reasonably accurate method of conducting preliminary volume studies to serve as a basis for more elaborate subsequent investigations, or indeed for the actual creation of space-volume patterns, where groups of stations can be computed together and where a high degree of exactness at any single point is not required.

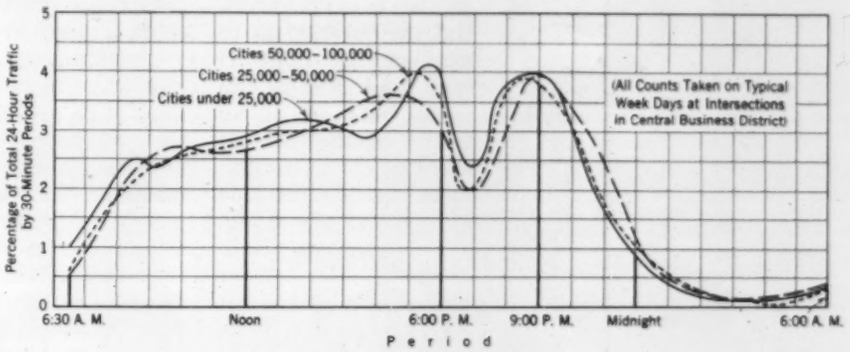

FIG. 2. TIME PATTERNS FOR URBAN TRAFFIC

In conclusion it may be said with confidence that time-volume traffic patterns have sufficient stability for use with suitable precautions in converting ascertained volumes for a short period into reasonably accurate totals for a longer period.

Determination of Losses in Travel Time

Resume of Recent Methods and Description of Equipment for Use at Critical Points

By E. W. JAMES

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IT was over a hundred years ago that the traffic census was first used in connection with highway development. It was introduced in France prior to 1844, but up to that time the observations were more or less desultory. After that date it became a regular part of French administrative practice. Its introduction into the United States occurred in 1885; and after 1906 it became rather common. The elements of the early census were a count of vehicles and the period of time in which the count was made. The complete statement of the record was the number of vehicles passing a given point on the highway in the period of the observation. This form of census gives a place-time relation for traffic and still remains the one most commonly used.

In 1924, A. N. Johnson, M. Am. Soc. C.E., Dean of the University of Maryland, introduced the element of distance into surveys made in this country, thus permitting the statement of a space-time relation for traffic. He used this relation in determining the maximum discharge of a traffic lane when vehicles are spaced according to the square of their velocity. Since then the use of the speed element in connection with traffic surveys has had interesting developments. Such studies generally refer to sections where speeds are reduced for a certain period of time, in which case they are commonly called delay studies.

In 1928, I used delay studies to determine the justification for grade crossing eliminations in the metropolitan area of Cleveland, Ohio. The space-time relation, or speed, of a determined number of cars was developed to show the total delay to all cars due to passing trains at a grade crossing. Other studies made in connection with the Cleveland Regional Survey determined the space-time relation for traffic over two or more different routes between the same points. These investigations served to show the possible saving in travel time over a belt line as compared with a route through a residential area or through the congested business section of a city. By combining the results of studies of this kind with the usual traffic counts, it is possible to determine the total saving in travel time due to a contemplated improvement.

DOES INTERSECTION CONTROL SAVE INSTALLATION COST?

Since the organization of the Division of Highway Transport of the U.S. Bureau of Public Roads, considerable development of the method has taken place. One of the first applications of it was to street intersections. The problem of determining the relative effect on traffic

of different methods of traffic control has never been solved. Observation has indicated certain gross advantages in the installation of control devices such as semaphores, stop-and-go lights, and manual control by traffic officers stationed at the intersection. But the question as to whether the cost of such methods is actually passed on to traffic in the form of a saving in travel time, or to what extent such cost is so passed on, remains unanswered. Obviously, an answer to these questions not only would determine whether the expense of a given installation or control is justified, but also would determine the limits of traffic density that would warrant this type of control. If the mere physical efficiency of an intersection were considered, that is, if safety were for the moment disregarded, the result would indicate a definite solution for each case, once the data were available for all conditions of control involved.

COUNTING VEHICLES ELECTRICALLY
Observer at Left Records All Vehicles Entering the Zone, and Observer at Right Classifies Those Leaving, on Three Keys

The delay to a vehicle at an intersection is due to deceleration, waiting for change of signal or for cars passing on the other route, and acceleration to the normal or usual speed prevailing along the route. To determine the total or average delay requires a count of the vehicles passing through the intersection and a determination of the loss of time for each car. The delay occurs between the point where deceleration begins and that where normal speed is resumed. This interval is the zone of influence of the intersection, and varies, of course, with the driver's habits and skill and with the type of the motor. It may also vary according to the density and composition of the traffic and the nature of the prevailing turning movements at the intersection.

When the average time required for a vehicle to pass through an intersection has been determined, the delay is found by computing the difference between the normal running speed adjacent to the intersection, but beyond its zone of influence, and the slower speed through the zone. Determination of these differences for a large number of individual cars or trucks would provide data for computing the average delay, but such a method is difficult in practice because each vehicle must be followed through and timed separately. Such a method is practicable only where traffic is very light. It will be found in practice that when delay studies are needed, the traffic is generally so heavy that only a small percentage of the individual vehicles can be timed by this method, and usually a poor sample results.

DELAY AT AN INTERSECTION MEASURED ELECTRICALLY

The U.S. Bureau of Public Roads has accordingly devised an electrical method that gives a time record, not of a sample of traffic, but of all the vehicles passing through an intersection on a given route. The data are obtained by a recording device having a chart driven at a constant speed, and equipped with electrically operated pens, which mark the chart as it passes under them. The pens are actuated by magnets connected in series with telegraph keys, and the keys may be located at any points to which wires can be carried. The recording chart is centrally located and receives the entire record.

To obtain the time spent in the zone of influence of a four-way intersection by vehicles entering on one of the four ways requires a recorder and key at the limit of the zone on each radiating street. The recorder at the beginning of the zone of influence records the time of the incoming vehicles by closing his key as each vehicle passes. All the other observers similarly record the outgoing cars, regardless of whether they have arrived from the right or the left, or have passed directly through the zone. Care must be taken in starting a run to make sure that recorders of outgoing cars do not start until the first recorded incoming car goes out. Likewise, at the end of the run the last car recorded as entering must be the last car recorded as leaving. Each recorder is provided with two keys connected to separate pens, and acts as an observer of both incoming and outgoing traffic.

If all right and left movements are to be separately recorded and the delay computed, two additional outgoing keys are supplied. By this means the entire intersection is controlled and, with minor but annoying exceptions, all movements of traffic in a four-way intersection may be recorded on a 16-pen instrument. Cars making U-turns in the intersection, or stopping there, as well as cars starting within the zone limits from domestic or public garages, gas stations, or parking positions, must be noted separately. The bureau uses a 20-pen instrument to provide additional keys for the recording of other essential data. The cost of installing the connections for the electrical recorder practically limits its use to single intersections whose zones of influence do not extend more than a few hundred feet.

There is no need of following an individual car through by eye or otherwise identifying it unless it is the first or the last. If a series of vehicles enters the intersection zone at times a, b, c, and d, and leaves at times a', b', c', and d', the total time, T, in the intersection is:

$$T = (a' - a) + (b' - b) + (c' - c) \ldots\ldots\ldots [1]$$

By grouping terms,

$$T = (a' + b' + c') - (a + b + c) \ldots\ldots\ldots\ldots [2]$$

This grouping permits entire disregard of the order or sequence of the cars on the street.

USE OF TIME CARDS

For time studies over distances of several blocks or several miles, different methods have been developed which have proved satisfactory. A time study in Alexandria, Va., gave an opportunity to use individual time cards. The conditions of travel for entering and departing traffic were such that speeds were not substantially altered by handing cards to drivers. The cards carried the station location and were stamped with a time stamp. At the end of the section the cards were collected from the drivers and again stamped with the time. The driver holding the card had nothing to do with the record except to accept and return the card itself. This method proved satisfactory for a density not exceeding 250 or 300 vehicles an hour.

An important qualification of any method used to observe and record the time spent by traffic on the road is that it should cause no change in the speed by introduc-

ing interruptions or by making the drivers self-conscious. The outstanding advantage of the individual time-card method is that every card is a valid record, requiring no sorting, comparing, or other preparation for analysis.

Development of timing methods on a large scale was necessary in the studies made by the bureau in cooperation with the State Highway Commission of New Jersey for the new viaduct across the New Jersey Meadows, where complicated disturbances of traffic flow occurred.

The operations proposed and ultimately carried out contemplated two distinct sets of observations. The first set was made before the completion of the new viaduct, when all traffic utilized the existing roads across the meadows and was interrupted by a variety of conditions, including several intersections of main routes, numerous intersections with minor cross streets, and two draw bridges.

Because of the quantity and speed of the traffic, it at once appeared impracticable to hand out and collect individual time cards, and in consequence three alternative methods were tried, each requiring that the license tags be read and recorded. It was found sufficient to record the last four digits of any license number, without reference to the state or other vehicle classification. In the three methods tested the records of license numbers were made: (1) by observers on individual cards marked with a time stamp; (2) on sheets covering an observation period and having each successive minute or fraction recorded; and (3) on what are called "minute cards," because each card is used for a separate minute. A study of the speed of recording, size of sample, and ease of analyzing, indicated that for passenger cars alone, when the flow is not more than about 1,000 cars an hour, individual time cards are best; but for general traffic, including passenger cars, light and heavy trucks, and busses, the minute cards afford the greatest facility and are usable up to 2,000 vehicles an hour in one direction without a sign of breaking down. They probably can be used successfully for practically any density possible on a four-lane road.

For the survey as finally organized, the minute-card method was adopted. One party was assigned to traffic in both directions at each end of the section observed. A complete party consisted of one observer for passenger cars for each traffic lane, one observer for trucks and busses for all lanes in each direction, and a time clerk to keep time and hand out new minute cards. Parties were also stationed at important intermediate points, where traffic left or entered the main route, and a similar record was made at such points.

The record obtained was so large that an analysis of it would have been practically impossible without punched cards and electrical sorting machines. The procedure was first to transfer the data to punch cards, each 45-column card being long enough to carry two independent records. The cards were then sorted and compared, matched cards being brought together. This method made it possible to secure the time and also the number of vehicles between turnouts, as well as between terminal points. At all stations a density count was taken.

After the opening of the viaduct a similar set of observations was made, and from these data the total delay saved by the construction of the viaduct was obtained. Any monetary value that is justifiable may be assigned to vehicle time to determine the total saving in cost to traffic. The result is a measure of the wisdom of building the viaduct.

Two other time-recording studies have been made by the bureau. The first of these sought to determine the time losses on a route through a city as compared with a by-pass, and to locate the points of loss. The apparatus consisted of an automatic camera equipped with a roll of moving-picture film, so arranged that a section of film, or frame, was advanced and one exposure made when a button was pressed. On the instrument board of an automobile a speedometer, clock, and odometer were installed and calibrated. The camera, which was secured to a standard between the knees of the recorder, was focused on these instruments.

ELECTRICAL TIME RECORDER SET UP IN A TRUCK
The 16 Wires from the Recording Keys Are Brought Together Here and the Data Recorded on a Time Strip

The car carrying the apparatus was driven with the stream of traffic. If one vehicle passed the observer's car, the observer in turn would pass one car, thus maintaining his relative position in the traffic stream. The camera operator made an exposure at each significant change of speed, took views of the instrument board at fixed time intervals, or followed any desired procedure in making exposures. The film then disclosed the speed, time, and total distance at any instant. From the prints a graph was drawn, which, with a set of parallel notes of street, road, or traffic conditions, clearly and easily identified and grouped the influences on travel along the route. Comparisons could be made with a proposed belt line, or with alternative routes, to determine the fastest line.

The last time-recording method developed by the bureau is for the determination of relative and absolute delays at given obstructions, such as grade crossings or draw-bridge openings. No special apparatus is required. Observers record the time when the first car is stopped, the time the speed of the last car is affected, and the total number of cars involved. The time of starting both the first and last cars is also noted. The average delay is then determined for the entire group of cars stopped.

EVALUATION OF TIME SAVED OR LOST

These methods represent the principal developments to date in introducing the time element in the traffic census in order to show the effects of traffic conditions or changes in such conditions. It is not necessary at present to attempt any evaluation of the time lost or saved. Such values may change from time to time and certainly will change with different types of vehicles. The methods outlined furnish data on the delay and will be adequate in themselves where mere comparisons are to be made. It is quite possible to assign any proper money value to the time saved whenever the costs of structures are to be justified.

Power Division Holds Joint Meeting

ON June 29, 1933, at the Society's Convention in Chicago, the Power Division met jointly with the Hydraulics Division of the American Society of Mechanical Engineers. At that time the Power Division's Committee on Legislation Respecting the Safety of Dams presented the report here abstracted. At the same meeting a paper dealing with the hydraulic resistance caused by bends in pipes, was read by Mr. Munroe and is also printed here in abstract.

The "Resume of the Engineering Reports on the St. Lawrence River Power Development," by Daniel W. Mead, Hon. M. Am. Soc. C.E., and the discussion presented by Thomas W. Hogg, M. Am. Soc. C.E., will be printed in full in the August issue of Proceedings, out August 15. Therefore no abstracts of them will appear in Civil Engineering.

Legislation on Safety of Dams

A COMMITTEE of the Power Division was appointed in 1930 to study and report on legislation in the various states respecting the safety of dams. This committee consists of L. F. Harza, Chairman; Robert A. Monroe, Subchairman; William P. Creager, Glen E. Edgerton, and William F. Uhl, all Members Am. Soc. C.E. At the time the committee was formed it was expected that numerous states would be enacting regulatory legislation which might be so restrictive as to prohibit development in the design of dams. It was hoped that the committee could be an influence in directing such legislation along sound lines.

Although the committee favors regulatory legislation in the interest of public safety in states where the failure of dams would cause damage to property and loss of life, it does not advocate the general promotion of such legislation by the Society. Rather, members of the Society should support or oppose such legislation in their own states as local circumstances indicate. After examining the regulations of various states the committee drafted a proposed regulatory bill, based in general on the California law. The proposed law places the responsibility for the exercise of authority with the individual state, which is to establish a department for that purpose in conformity with its own particular governmental organization. Section 1 provides for the administration of the law by some designated state authority, which ordinarily would be the state engineer. If the engineering talent available in the permanent organization of a state is not of sufficiently high character, full advantage should be taken of the authority to employ qualified consultants as needed.

Section 2 defines a dam as a structure for impounding or diverting water that is 15 ft or more high from ground level to spillway crest, and which has an impounding capacity of 100 acre-ft or more. Section 3 makes it unlawful to construct, alter, or operate a dam without the approval of the state authority. In Section 4 it is required that the owners of each dam completed prior to the passage of the act obtain either a certificate of approval from the state authority or orders directing necessary alterations. The sections that follow detail the methods of filing applications for the construction or alteration of dams and the time limit for completion.

The proposed act provides for either continuous or periodical inspection during the construction or alteration of all dams and gives the state agency authority to stop any work not approved by it. The department is required by the act to supervise the maintenance and operation of dams as may be necessary to safeguard life and property and is authorized to issue rules and regulations to the owner to secure safe maintenance and operation.

Owners or operators of dams are not relieved of any legal duty or responsibility, obligation, or liability incident to their ownership or operation, and no action may be brought against the state or its agents for the recovery of damages due to failure of a dam by virtue of the state supervision and control of its construction and operation.

In cases of disagreement between the owners of a dam and the department, provision is made in the proposed act for a board of arbitrators composed of three disinterested engineers, one to be appointed by the owner, one by the department, and one by the two members of the board thus named.

The proposed act is suggested as a guide to those drafting such a law in any state. Certain modifications may be required to fit local conditions.

Friction Losses in Pipe Bends

ENGINEERS of the U.S. Department of Agriculture, in cooperation with the University of Iowa, are conducting novel and interesting experiments on the resistance that pipe bends or elbows offer to the flow of water. A report on methods and results, prepared by D. L. Yarnell and Floyd A. Nagler Members, Am. Soc. C.E., was presented before the Power Division on June 27, 1933.

Pipes and elbows of transparent celluloid made the turbulence in the moving water visible for study and analysis. An instructive and entertaining demonstration of how excessive turbulence causes increased resistance to flow was given by means of motion pictures. The test data will be of great value to engineers in designing pipe layouts for pumping plants, hydro-electric plants, and all apparatus carrying liquids.

From an engineering standpoint the tests are illuminating, as they show that the resistance to flow offered by pipe elbows varies not only with the velocity of the water and the roughness of the interior of the pipe, but also with the velocity distribution in the pipe at the approach to the bend. It is possible to have conditions of flow such that the resistance to flow will be very small or unusually large in the same bend, even when identical quantities of water are carried. With a high velocity on the inside and a low velocity on the outside of the tangent pipe leading to the bend, the loss of head may be about five times as much as that found in the same bend when there is a high velocity on the outside and a low velocity on the inside in this pipe section.

Excessive turbulence in the flow of water around pipe bends causes energy losses and, by straightening out the direction of the filaments of water, increases the efficiency. New shapes of bends were tested with this end in view. The results to date have been very encouraging

Basic Surveys for Engineering Works

A Century of Experience Proves Their Economic Value

DETAILED information as to topography and location of existing improvements is essential to the economic planning of all engineering works. In any construction or city planning project the cost of the basic surveys is an insignificant part of the total expenditure involved and should not prevent governing bodies from appropriating sufficient funds for the preparation of the proper maps.

A logical sequence of ideas is traceable in the two articles which follow. In the first, Major Bowie explains that, at the present rate of progress, the control surveys of the U.S. Coast and Geodetic Survey will be complete in another ten years, so that a triangulation station and bench mark will be within 15 miles of any point, except in rugged mountain areas. For his part, Mr. Whitmore reviews the history of city surveys during the past century, concluding that most cities would be far better off if they had reversed the order of their growth—construction, planning, surveys—and had started out with a comprehensive program of surveying and mapping. These articles are abstracts of the papers presented before the meeting of the Surveying and Mapping Division on June 29, 1933, at the Society's Annual Convention in Chicago.

One Hundred Years of Control Surveys

By WILLIAM BOWIE

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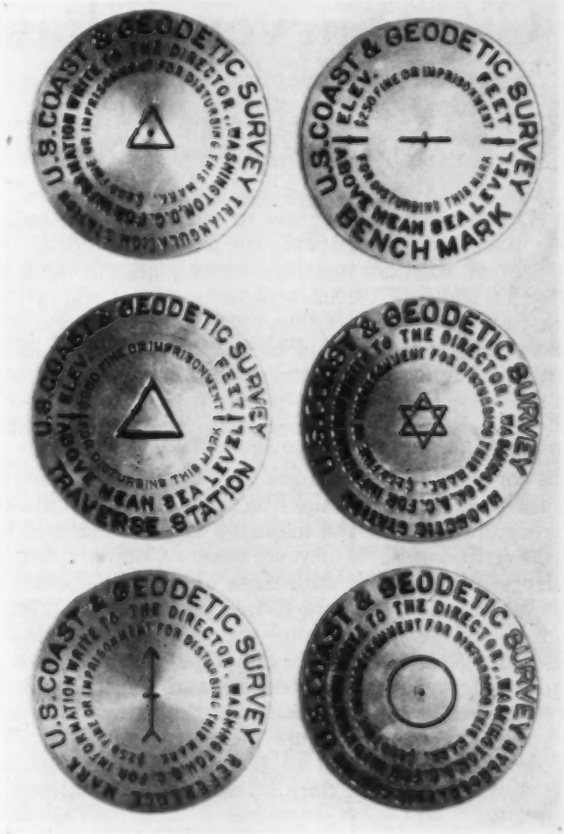
IN most engineering operations a knowledge of distance, direction, and elevation is essential. This information is furnished by geodetic or control surveys, which may be nation-wide in extent or of a purely local character. The data for horizontal control surveys are also of value in perpetuating the boundaries of public and private land. When boundary surveys are connected with the national triangulation net, boundary corners can be reestablished at any time even though the nearby triangulation stations have been destroyed.

Control surveys, which a hundred years ago were used merely as the framework for topographic and hydrographic surveys along the coasts of this country, have since been greatly extended in large nets of triangulation arcs and lines of levels. There are now in the triangulation net 38,000 miles of arcs, and in the level net, 80,000 miles of lines of leveling. At the present rate of progress the control surveys will be practically completed within the next ten years, as far as the first and second-order work is concerned. The U.S. Coast and Geodetic Survey, which is now executing practically all the fundamental control surveys of the country, is following a plan that calls for the spacing of the arcs of triangulation and lines of levels about 25 miles apart. It will be seen that when these nets are completed there will be no place, except in rugged mountain areas, that will be more than 12 or 15 miles from a triangulation station or leveling bench mark.

More triangulation and leveling have been done in this country in the past decade than during the previous ninety years, a fact that is mainly due to the increased interest taken in control surveys by engineers, property owners, and others. This is especially true in the case of city engineers and those in charge of the extension and construction of highways. With this increased interest on the part of the people has come an increase in the appropriations allotted for the work.

During the past few years final adjustments of the triangulation and level nets of the country have been made. In the early days it was desirable to adjust the arcs as they were run, in order to furnish the resulting data to engineers and others as quickly as possible. New arcs were adjusted to fit the old and eventually loops were closed. Then, in order to continue holding fixed the old data, the closing sections of the loops had to stand the corrections necessary for adjustment. As a result, corrections were applied to new work of high



STATION MARKS USED BY THE U.S. COAST AND GEODETIC SURVEY

grade that were out of proportion to the accuracy of the observations.

The triangulation net, including both new and old sections, has recently been adjusted as a single unit. In order to do this it was necessary to devise some practical way of overcoming the difficulties imposed by a rigid mathematical treatment of such a mass of data. A satisfactory method was devised by the author, the details being worked out by Dr. O. S. Adams of the U.S. Coast and Geodetic Survey. The level net too has been adjusted as a unit, and it now appears that both adjustments are so thorough that no further changes will have to be made in the resulting geographic positions and elevations except in those cases where triangulation stations or bench marks may be disturbed by earth movements. It appears probable that the areas in which such movements will occur are very restricted.

There has been a gradual improvement in the instruments and methods used during the past one hundred years. The engineers of the Coast and Geodetic Survey have been in close contact with geodetic engineers of other countries through the International Union of Geodesy and Geophysics, through the exchange of publications, and through correspondence. Advantage has been taken of scientific development, especially in the field of physics, to improve the instruments and apparatus employed on the control surveys.

During this period many difficult problems have arisen in both field and office work—in the measurement of horizontal angles and base lines; in the determination of astronomical latitudes, longitudes, and azimuths; and in the running of levels. After careful study, nearly all these problems have been solved with a marked degree of success.

RADIO AN AID TO ACCURACY

In astronomical work the greatest improvement has been in the method of determining differences of longitude. One hundred years ago determinations of longitude depended upon observations of the moon and the transportation of chronometers. Later came the telegraph and now there is the radio by means of which to compare time pieces at distant points. At present a longitude station can be established at any point to which the instruments can be carried.

The triangulation net of the United States has been computed from a single initial station, Meade's Ranch in Kansas, and it is all on the same spheroid of reference, that of Clarke, of 1866. The elevations of the bench marks in the level net are based on mean sea level as determined by observations at 26 tidal stations on the Atlantic, Pacific, and Gulf coasts. The triangulation nets of the United States, Canada, and Mexico form a single unit, and the level nets of Canada and the United States were used together in the adjustment that furnishes standard elevations for this country. Presumably the elevations resulting from this adjustment will be adopted for Canada also.

The standards of accuracy of the geodetic or control surveys of the United States are at least as high as those set by the International Association of Geodesy, and they meet all the practicable requirements for control surveys.

City Surveys—Past, Present, and Future

By GEORGE D. WHITMORE

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VICE-PRESIDENT AND ASSISTANT CHIEF ENGINEER, R. H. RANDALL AND COMPANY, INC., TOLEDO, OHIO

ANY account of progress in surveying methods in American cities during the past one hundred years must consider matters of city growth and land policy in addition to the technique of surveying itself. Also, in view of the fact that the history of surveying improvements in this period is well known, it is perhaps more important to stress the present status of metropolitan surveys, the apparent trends in technique, and the indications of increased demand for, and use of, good survey and map information.

In considering the changes that have taken place during the past century in the functions of city government, it is significant that the majority of these changes have to do with public utility services. Compare the city budgets of the present with those of a hundred years ago. The largest item in cost today (exclusive of relief for unemployed) is public improvements. An analysis of these changes and trends in municipal services, with particular reference to engineering and construction features, shows, generally speaking, that the construction and operation of public improvements came first. Then followed the realization of the need for city planning and zoning. Finally, during the last ten or fifteen predepression years, city governments came to realize that comprehensive surveys and maps were necessary. It is now clear that these gradual changes have occurred exactly in reverse of the ideal order. The cart has been ahead of the horse for a hundred years. The logical order would be of course: first, surveys and maps; second, city planning; and third, construction.

There is still ample opportunity for cities to reorganize their surveys and maps on a sound basis, and use them to avoid in some degree the blunders of past city building. All predictions by competent observers indicate that our cities are just entering a period of great physical change brought about by changed habits and higher standards of living, and by improved means of transportation and communication. Cities must prepare both for these fundamental changes in physical pattern and for an immediate resumption of public works on a national scale. This construction program, though fostered by the Federal Government, provides that a large part of the work is to be done in and by the cities. Because of these two factors, city governments will surely follow the logical program of securing, first, basic surveys and maps and then a thorough city plan, so that they will be well prepared for the period of city construction and reconstruction which is soon to begin.

Probably the most that can be said of the city surveys of a hundred years ago is that, with a few notable exceptions, they did not exist. By the beginning of the twentieth century American cities were commencing to

take stock of their assets and liabilities in survey and map data. During the years from 1900 to 1915 a few of the larger cities, including Baltimore, New York, and Cincinnati, realized the necessity for a basic, coordinated system of surveys and maps. They were the pioneers in this field in America. Based on the experience of those cities, of the Federal surveying and mapping agencies, and of European cities, there has been gradually formulated a schedule of surveys and maps that is now almost universally acknowledged as the minimum requirement. Between 1915 and 1930 at least thirty cities or metropolitan areas adopted comprehensive programs of surveying and mapping.

CITY SURVEYS CLASSIFIED

The schedule of surveys and maps commonly called the "city survey," and universally accepted as standard today, may be classified broadly in two general divisions. The first of these is the control, or framework, of horizontal and vertical surveys of high precision. The second comprises detailed surveys and maps based on this control.

Horizontal control consists of a triangulation net covering the entire area, of an accuracy of one in 100,000, with stations averaging from one to three miles apart. This is followed by a first-order traverse survey, which originates and closes on the stations of the triangulation, has permanent monuments for station markers, and has an accuracy of one in 30,000. The first-order traverse lines are located on the principal streets, where the stations are readily accessible for every-day use, and are so distributed that no point within the area is more than a half mile distant from a station. The vertical control consists of first-order (precise) levels, paralleling the first-order traverse routes, and utilizing the traverse monuments as bench marks, as well as establishing additional bench marks on substantial buildings and masonry structures.

MEASURING A BASE LINE WITH MODERN EQUIPMENT
One of the First Steps in Establishing a City Triangulation System

The detailed surveys and maps which follow the control net include large-scale topographic maps, usually 200 ft to the inch; property maps showing the dimensions and coordinates of public and private properties; and underground maps giving the type, location, and elevation of all structures on or under the streets. The schedule is completed with a small-scale map of the area, usually 1,000 ft to the inch, and an aerial mosaic on the same scale.

The principal specifications governing the triangulation

Observer and Theodolite Protected from Sun and Wind

Chimney Station Established for Daylight Observation

CHIMNEY LOCATIONS OFTEN REQUIRED FOR TRIANGULATION STATIONS

are: the stations shall be so situated that triangles of high strength result, with ground base lines located at intervals frequent enough to ensure a final accuracy of one in 100,000; the average error in triangle closure shall not exceed 1.5 sec, and the maximum shall not exceed 5.0 sec; base lines shall be measured with a resultant probable error not exceeding one in 600,000, using standardized equipment throughout; final adjustment shall be by the method of least squares; and rectangular coordinates shall be computed for all stations, and shall be the basis for all future surveys and maps.

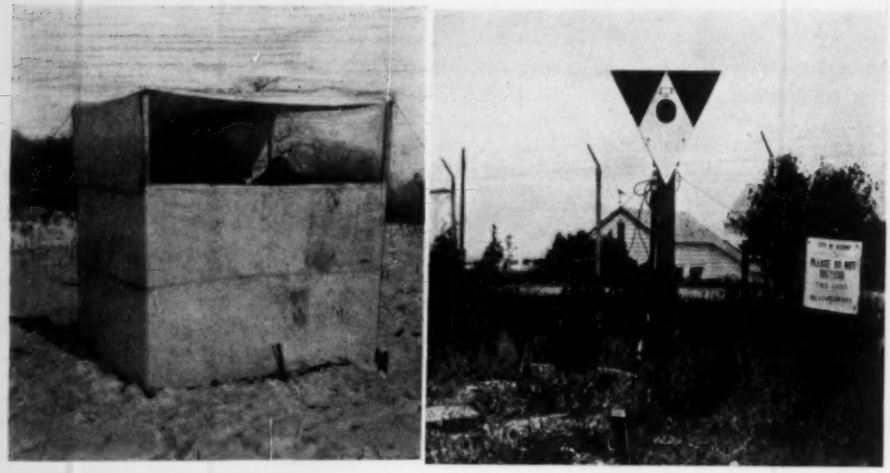
TYPES OF INSTRUMENTS USED

Theodolites used for angle observations are of either the direction or repeating type, capable of determining an angle within one second, exclusive of uncontrollable atmospheric interference. The city triangulation should be connected to the first-order triangulation of the U.S. Government if stations are available for the purpose. It thus becomes a part of the national triangulation net, preserves for eternity the location of the stations of the city survey, and furnishes geodetic azimuths.

First-order traverse is best described as essentially a series of connected second-order triangulation base lines, with the angles between these lines measured by triangulation methods. The principal specifications are: the average angular error, computed from circuit closures or between triangulation azimuths, shall not exceed $\frac{4 \sec \sqrt{a}}{a}$ per instrument station, and the maximum shall not exceed $\frac{6 \sec \sqrt{a}}{a}$ per instrument station, a being the number of instrument stations on the line; and the average position closure, after distribution of azimuth errors, shall not exceed one in 30,000, and the maximum shall not exceed one in 20,000, whether computed in circuits or between fixed coordinates of the triangulation stations. Such accuracy gives satisfactory results.

Field equipment and methods are practically the same as those for triangulation. The repeating instrument is usually better suited for the angular measurements than the direction theodolite. Either steel or invar tapes may be used for distance measurements, but they should be standardized frequently by comparison with a local standard of length.

For first-order levels the principal specifications are: the datum of elevations shall be mean sea level as furnished by the first-order levels of the Federal Government; and all levels shall be double-run, the discrepancies between forward and backward runs not to exceed 0.017 ft $\times \sqrt{M}$, in which M is the length of the section in miles.



AN OBSERVATION AND SIGNAL STATION LOCATED ON THE GROUND
Signal Station Equipped for Night Observation

For leveling, the instrument known as the U.S. Coast and Geodetic Survey Precise Level should be used. This assures accurate measurement at a high rate of speed. The rods, probably of greater importance than the instrument, should be jointless, and the fine graduations should be painted on a ribbon of invar metal. This type of rod eliminates errors due to changes in length caused by changes in temperature or humidity. The absolute length of the rods should be determined by the U.S. Bureau of Standards.

TRENDS AND CHANGES IN TECHNIQUE

Perhaps the most pronounced change in the technique of city surveys during the past one hundred years has been in the general acceptance of the plane table for mapping purposes. Most engineers can remember when no procedure was known for mapping on a large scale except that by transit stadia or gridiron. Today the statement that the plane table is the best method for city topographic mapping on a scale of 200 ft or larger is rarely challenged. Results prove conclusively that under ordinary conditions a map to a scale of 200 ft can be constructed by plane table at a cost well below that possible by any other method.

Another definite and logical trend in city survey procedure has been the general adoption of engraved-lithographed reproductions for topographic maps. These reproductions cost only slightly more than tracings and blueprints, are accurate for scale, and have practically none of the paper distortion that is characteristic of tracings and wet-developed blueprints. Also, they permit a much finer and clearer line, thus showing all the detail that can be given on the original. Printing in four colors offers the obvious advantage of absolute clearness, which is not possible in a one-color reproduction.

For the property map and underground-structure map a large scale is needed, usually 1 in. = 50 ft. Since these maps show dimensions, exact scaling is less important, and consequently they may be reproduced by tracing and blueprinting.

In making these maps the main requirement is that all street corners and street angle points be connected by traverse surveys to the stations of the first-over traverse or triangulation. Thus rectangular coordinates can be established for all street property points, and their exact locations preserved forever. For simplicity, ease of computation, and permanence, no method has yet been devised which can compare with that of rectangular coordinates.

BASIC SURVEYS SAVE MONEY

Any city that possesses the schedule of surveys and maps described need not fear to face squarely advance planning for the growth and change that are sure to come. These basic surveys make it possible to discard the wasteful, inadequate, piecemeal system of making an individual survey for each new study, and supply instead full information about the ground and the property divisions. Complete general planning is a logical sequel, and this consideration alone more than justifies the cost of the city survey. Later, when individual projects need to be studied and designed, the maps are even more useful. They supply practically all the necessary engineering data, so that various ways of locating or building each improvement may be studied, the merits of alternative plans considered, and costs compared.

By way of summary, it may be said that the progress made in city surveys during the past one hundred years has been mainly in the more general realization of their necessity and economy. This does not imply that major improvements in methods, equipment, and results have not taken place, for considerable advancement in these directions has been attained. But the greatest factor in progress is the realization by engineers, city planners, and Government officials of the need for this fundamental survey and map information.

Today city governments are offered a wonderful opportunity to construct basic surveys and maps and use them to the fullest advantage in the approaching period of public works construction and city reconstruction. There has never been a time since pioneer days when an adequate city survey could be so useful, and certainly it could never have been made at less cost than is possible today. The past century has proved conclusively that most American cities would have been far better off if their first undertaking had been a comprehensive surveying and mapping program.

Assuming that city governments have the intelligence and foresight to do what it is now apparent to engineers should be done, and that engineers have the courage of their convictions and will actively promote the idea, then the future of the city survey appears to be principally in maintaining and keeping up to date the basic survey structure.

OUR READERS SAY—

In Comment on Papers, Society Affairs, and Related Professional Interests

Single-Thickness Slab for Rock-Fill Dams

To the Editor: The Arizona code covering the design and construction of dams was clearly reviewed by Mr. Fraps in the April and May issues. While space does not permit a full discussion, I desire to take issue with certain of the code provisions relating to rock-fill dams.

The Arizona code rightly lays great stress on the importance of providing an impervious upstream face. The single-thickness slab for either high or low dams has been widely and successfully used and will perform perfectly provided proper precautions are taken in its design and construction. At Salt Springs Dam the concrete face, some 9 acres in area, has performed perfectly at all points except along the periphery of the canyon walls, where the type of connection used did not afford sufficient flexibility to prevent the formation of cracks. The area affected by cracks that are in sight with minimum reservoir level is only 5 per cent of the total area of the face, and if the same width of cracked area extends across the bottom, the area affected is but 8.6 per cent of the total area of the face.

The location and type of joints in the vicinity of the cut-off wall and the abutments are of major importance for either the single or multiple-slab type of concrete facing. At all other locations either type should provide ample flexibility.

The requirement that lifts shall be 20 ft apart vertically or less for minimum settlement is not in accord with experience in the construction of the Salt Springs Dam. The methods outlined restrict flexibility in construction methods, and the resulting fill is not superior to, if as good as, the fill resulting from the use of high lifts. The heights of lifts at Salt Springs Dam ranged from about 35 ft to as much as 165 ft. The major yardage was placed from lifts of 165 ft (maximum distance to bedrock), 70 ft, and 84 ft. The rocks in rolling through greater distances tend to make the fill more compact by force of impact and because more rock points, thin edges, and weak rocks are broken than in the case of the low-lift work. Slides frequently occur as the fill progresses, and these tend to further break off and wear down the points and edges, and cause added compaction.

A comparison of settlements of the Strawberry and Salt Springs dams, both constructed of excellent granite, is offered to substantiate this contention. The maximum vertical settlement of Strawberry Dam in the first 22 months after completion, was 0.93 ft per 100-ft depth of fill. The rock fill was made by dropping the rocks from cableways, the maximum drop being less than 30 ft. The corresponding settlement at Salt Springs in the first 23 months after completion was 0.38 ft per 100 ft of fill.

While my experience is in accord with the provision that the downstream slope shall not be steeper than the natural angle of repose of the material in the fill, it is not in accord with the additional ruling that it shall not be steeper than 1.4 to 1. This latter provision is not objectionable for very high dams, but it imposes an unnecessary hardship in building rock-fill dams of moderate height, because in most instances it would be necessary to provide benches in the downstream face or use other than the usual methods of construction in order to obtain a slope flatter than the natural angle of repose.

While no criticism is offered of the requirements that structures in excess of 100 ft in height shall have a minimum crest width of 16 ft, the 12-ft minimum crest width is unduly severe for dams under 50 ft in height.

I. C. Steele, M. Am. Soc. C.E.
Chief of the Division of Civil Engineering
Pacific Gas and Electric Company

San Francisco, Calif.
June 21, 1933

Silt Movement at River Bends

Dear Sir: The article, "Flow in River Bends," by H. D. Vogel and Paul W. Thompson, in the May issue, can be interpreted as complete refutation of the helicoidal flow theory heretofore offered to explain the lateral movement of silt at bends. The new theory affords a basis for analysis of bend phenomena amenable to much simpler natural laws than is possible with the so-called helicoidal flow theory.

The article explains that the lateral movement is produced by turbulence of the water in the direction of decreasing velocity. Since this explanation may not satisfy advocates of the helicoidal flow theory, it is proposed to offer a simpler explanation of the phenomena.

Tractive force, turbulence, velocity, slope, and helicoidal flow, when they exist, are results of a quantity of water endeavoring to flow although opposed by resistances to flow. Resistances to flow include, principally, friction along bed and banks, expansion and contraction of channel, bends, and obstructions. Tractive force is the reaction to resistance to flow. Resistances to flow create turbulence, and turbulence is inherently associated with tractive force. The various forms of resistance to flow, singly or in combination, create various degrees of turbulence. Perhaps the term "turbulence" should never be used in the sense of expressing or denoting creative properties.

When turbulence exists, certain phenomena occur, according to the degree of turbulence, not as a result of turbulence but because of the condition that caused it. Turbulence is merely a useful term for expressing character of flow. Probably the best method of comparing relative degrees of turbulence at two locations may be expressed by the products of ds at the respective locations, in which d = depth and s = slope, since d and s are applicable only within limited areas of the two or more localities being compared. A practicable means of determining relative turbulence probably can be developed by use of two current meters, one of the bucket type checking against another of the screw or impeller type. (See Transactions of the Society for 1931, page 767.)

When flow is turbulent, it is accompanied by erratic velocities, and the greater the degree of turbulence the more erratic are the velocities; that is, the greater will be the relative difference in intensity of velocities between adjacent filaments of water or between adjacent separate small volumes of water. Since any velocity represents a pressure, due to velocity, which is directly proportional to the square of the velocity ($h = \frac{v^2}{2g}$), it follows that filaments and small volumes having the higher velocity will have the higher pressure, and that adjacent filaments and small areas of less velocity will have lesser pressure. The ratio of intensity of pressures between filaments or between small areas and volumes will vary as the square of the velocities. Hence not only will the filaments or the areas of high pressure expand toward the low pressures (velocity), but any particle in suspension or the moving bed load will be impinged toward the zone of lesser pressure (velocity). It is the turbulent character of flow, resulting from upward expansion of differences in pressure, that holds particles in suspension and not the upward component of velocity often erroneously assigned as a cause of suspension.

The experiments of Lieutenant Vogel have established beyond doubt true principles of silt movement. The new theory should be welcomed by the engineering profession, since it is believed that, in combination with principles of tractive force, it will open a field for new thought and investigation not heretofore available on the basis of the various helicoidal flow theories previously held.

Guy B. Bebout
Principal Engineer, U.S. Engineer Office

Vicksburg, Miss.
June 26, 1933

Effect of Overgrazing Upheld

TO THE EDITOR: In discussions of my article in the February issue, entitled "Influence of Overgrazing on Erosion and Watersheds," the outstanding feature has been the almost universal failure to recognize the influence of a vegetative cover on the movement of soil, the so-called balance between soil building and soil destruction. This, I reiterate, is the only factor within the control of man, which can and does exercise a definite influence in reducing erosion and diminishing the silt content of streams. It is possible to diminish or even to destroy this vegetative cover by unregulated overgrazing. There has been no regulation of grazing on the public domain and there has been, as a result, continuous overgrazing from the time that cattle and sheep were first introduced.

EFFECT OF A SINGLE CLOUDBURST IN TEHACHAPI CANYON, CALIFORNIA, SEPTEMBER 30, 1932, IN WHICH 4.8 IN. OF RAIN FELL

Heavy Overgrazing Had Removed the Protective Vegetation. The Influence of a Single Tree with Its Accumulated Ground Cover of Twigs and Leaves Is Clearly Shown

Despite the arguments centered on the effort to disprove my contentions, I stand by every statement made and could add many more instances. On the other hand, neither I nor any other forester has ever advocated the general exclusion of grazing (as one writer stated) as a necessity for control of erosion. We are heartily in agreement with the resolution approved by the American Engineering Council, quoted in the May issue, and have been actively working for such control for decades, regardless of what political agency or bureau should exercise it.

A second characteristic of the discussions is the utter neglect of time values when dealing with geological processes. What took place millions of years ago under entirely different climatic conditions is of no interest to the present generation. For instance, the caption under the photograph of the arroyo in Chaco Canyon (June issue) which reads, "This valley has been filled, cut, and refilled time and again," is entirely misleading. The irrefutable evidence of the location and construction of Pueblo del Arroyo on the valley floor in 864 A.D. and the examination of the arroyo, which proves that since that date and up to the time when the Navajos introduced sheep, there was no arroyo in this valley at this point, is the only important fact bearing on the present question. Likewise, the caption of a photograph in the May issue that reads, "Terraces are especially susceptible to erosion, and these have not escaped," tends to conceal the fact that the terraces did escape gullying up to within the last 30 years and are now, for the first time since they were formed, showing excessive erosion.

Two additional facts bearing on this subject may be cited. In 1910 the Farmers' Union Reservoir was constructed on the headwaters of the Rio Grande. The watershed in this instance was thoroughly protected by a vegetative cover, mostly forest. In 1930 this reservoir was drained for repairs. So little sediment had collected that photographs show the wagon tracks of the original road which traversed the bottom of the reservoir. By contrast, on a large area of public domain in western Colorado, between the White and Colorado rivers, east of Rangeley, the wagon tracks made by the original settlers in removing juniper now end abruptly at the brink of yawning gullies, and the entire area is eroding at a rapid rate and dumping excessive quantities of silt into these rivers. The effect of vegetation cannot be prejudged by its relative scantiness, unless a full picture of the roots is seen.

In conclusion, I bespeak the cooperation of engineers in recognizing a condition whose seriousness has only recently become apparent. Foresters as a class have no ax to grind in this matter and have themselves only recently been forced to recognize cause and effect. Several unpublished reports in the files of the Forest Service contain a wealth of detailed information, all pointing to the same conclusion. If these are facts, they will ultimately be recognized by all whose well-being is dependent on irrigation and water control.

H. H. CHAPMAN
Professor of Forest Management
Yale University

New Haven, Conn.
June 16, 1933

Problem of Sheet-Pile Design

TO THE EDITOR: It is difficult to see how the data presented in the article, "Resistance of Sheet Piling to Overturning," by Professor Krynine and Mr. Abbett, in the May issue, warrant the conclusions that have been drawn.

The experiments are interesting and, when their details are published, will undoubtedly prove of value as an addition to the body of experimental data on the subject. But the attempt to explain the failures of anchored bulkheads on the basis of these experiments does not seem justified.

The failure of the anchored bulkhead at Industry Haven, Stettin, Germany, was in no way connected with its action as a free standing wall. As described by Dr. Ing. H. Cantz, the failure occurred at the anchored end of the tie rods, and was largely due to the excessive load induced by the settling fill pressing down on the unsupported tie rod. After the partial failure of the anchor, the wall bulged, as would be expected. It would be illogical to expect a wall requiring a support at the top to have sufficient strength and rigidity to stand without large deflections when this support is removed. Upward bulging of the soil and the development of cracks, as shown in the experiments made at Yale University, would not be expected in this case.

In the case of the steel bulkhead in Connecticut, it is questionable from the data given whether the cracks shown are due to the cause stated in the paper, or whether they are slip cracks formed as the soil followed the deflecting wall. Information as to whether the soil bulged or settled between Crack *a* and the bulkhead would settle this point.

The suggestions for the design of sheet-pile bulkheads do not seem to be justified by any data presented in the article. In this connection it might be stated that a very excellent discussion of the problem of sheet-pile design is presented by Dr. Lohmeyer in *Die Bautechnik*, 1930, No. 5, and later in the fourth edition of *Der Grundbau*, by Brennecke-Lohmeyer, Vol. 2. The logic of this theory and its practicability as a design method recommend it strongly. Its accuracy has been checked on a large-sized model and found to be remarkably good. So far as is known, no description of this method has ever been published in English.

F. J. CONVERSE, ASSOC. M. AM. SOC. C.E.
Instructor in Civil Engineering
California Institute of Technology

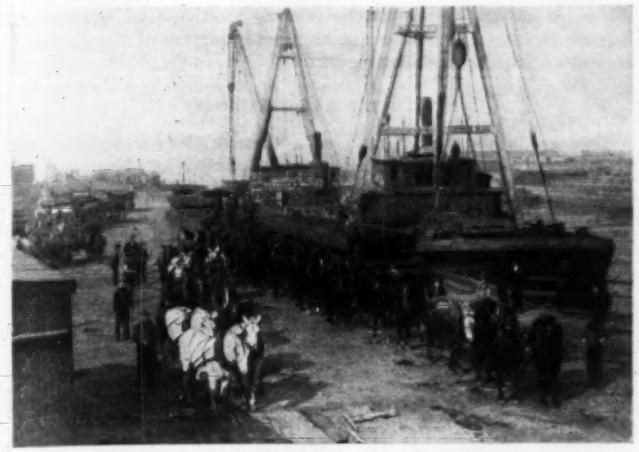
Pasadena, Calif.
June 26, 1933

Fifty-Four Horses to a Girder

TO THE EDITOR: When reading the paper, "Hauling and Erecting Large Steel Girders," by Mr. Rapp in the July issue, I was immediately reminded of the contrast between the methods used today and those of barely a quarter of a century ago. The author

speaks of trucks, trailers, heavy shovel carriers, donkey engines, and caterpillar cranes of 15 tons capacity. All this equipment has made remarkable advances and none more so than in the one item "power."

In 1909 the lower part of the New York City post office at 34th Street and Eighth Avenue was being constructed above the tracks



A 55-TON GIRDER ON TRUCKS DRAWN BY 34 HORSES

of the Pennsylvania Railroad by my father, Charles H. Peckworth. The long and heavy girders necessary to carry the load of this building across the railroad tracks were delivered at the dock at the foot of 38th Street and the Hudson River and were pulled across town to 34th Street and Eighth Avenue by means of horses. The girders were jacked around the corners into the narrow cross streets.

The accompanying photograph was taken on November 12, 1909. It shows a 55-ton girder on trucks drawn by 34 horses. A girder weighing 74 tons required the combined efforts of 54 horses. These were only two of many such girders used in the construction of this building.

It might be added that when 54 horses started up the street with a 74-ton girder behind them, they could not be stopped with the precision of a modern hydraulic brake. The journeys that large girders make from the dock or flat car to their respective jobs are not the least interesting phase of construction work.

HOWARD F. PECKWORTH, Assoc. M. Am. Soc. C.E.
Assistant to the Chief Engineer
Slattery-Daino Company, Inc.

New York, N.Y.
July 5, 1933

A Woman's Share in Brooklyn Bridge

DEAR SIR: The article by Mr. Byrne on the Brooklyn Bridge, in your June number, revives much valuable information in connection with the construction.

A few people still living, like myself, remember one personality whom, I am glad to note, Mr. Byrne did not omit from the roll of honor of those deserving great credit for this accomplishment. I refer to the splendid and difficult services performed by Mrs. Washington A. Roebling. She was a most charming and cultured woman and rendered invaluable help to her husband throughout his long illness occasioned directly by his fidelity to this work.

Some day it is to be hoped that the complete history of this bridge will be suitably written, but that is a laborious task. In such a record Mrs. Roebling's contribution merits a large place.

GUSTAV LINDENTHAL, Hon. M. Am. Soc. C.E.
Consulting Engineer

Jersey City, N.J.
June 15, 1933

Formula for Wave Velocity in Open Channels Verified

DEAR SIR: The article by Professor King on "Translatory Waves in Open Channels," in the June issue, is very interesting. The subject matter has many engineering applications, of which the profession apparently remains in ignorance.

The following comments are confined to the common type of flood wave or waves produced by flow increments from water power plants or storage reservoirs. The face of such a wave, which is subject to friction, as Professor King states, is not vertical as it is in his Fig. 1. His Formula 1 for wave velocity, however, still holds true. If the channel width considered is greater or less than unity, D in the formula (depth times unity) becomes D times width or the area. Formula 1 may then be expressed $v_w = \frac{Q_2 - Q_1}{A_2 - A_1}$. This expression for wave velocity was first presented by the late James A. Seddon, M. Am. Soc. C.E., in the TRANSACTIONS of the Society for October 1899.

After making various experimental studies and investigations, I have arrived at certain conclusions on the subject of translatory waves moving downstream, and subject to channel friction. These are as follows:

1. The Seddon formula, $v_w = \frac{Q_2 - Q_1}{A_2 - A_1}$, correctly represents the wave velocity after the wave is formed.

2. During the period of formation of a wave due to a sudden increment, $Q_2 - Q_1$, the mean velocity of advance of the toe of the forming wave is about 1.4 v_w.

3. If the stage-discharge curve and stage-area relation for a reach of a channel are known, the wave velocity for any increment of discharge at any stage is readily determined.

4. For a given increment of flow in a given channel, the wave velocity increases with the stage. At high stages the wave velocity, v_w, approaches a constant.

5. At high stages the wave velocity (v_w) is from 40 to 100 per cent greater than the mean velocity (V_2) of the water flowing in the channel upstream from the wave crest.

6. Under a sustained increment of flow the water surfaces above and below the wave (D_2 and D_1) remain constant.

7. If the increased flow stops, the water surface behind the wave crest falls to the original flow line. The velocity of the tail of the wave decreases to the original velocity of the stream, while the crest of the wave tends to advance with its original velocity, $v_w = \frac{Q_2 - Q_1}{A_2 - A_1}$. This lag of the tail results in a gradual elongation accompanied by a corresponding gradual decrease in the height of the unsustained wave. This unsustained type of wave is the one commonly observed in hydrographs of run-off in natural streams.

8. The front of the wave is not vertical. It is a relatively flat slope. The bulk of the volume of the wave front is included in a parabola, convex upward, and tangent to the flow line at the crest of the wave. A minor volume of the front or toe of the wave is included below a curved water surface, concave upward, tangent to the downstream flow line and the parabola. The length and shape of the wave can be computed.

The phenomena and laws relating to translatory waves in stream channels apply to the forecasting of river stages and floods and the time effect in river regulation from storage or water power reservoirs. Time of transit is commonly computed from stream velocity when wave velocity (v_w) should be used. This applies to the derivation of the time of concentration. In applying the storage equation (inflow = outflow ± storage) to the computation of run-off from rainfall, I failed to meet the obvious requirements of this equation when stream velocities were used. Finally, however, by substituting wave velocity for water velocity, I obtained results that met the storage equation exactly. In general, wave velocity applies to all cases of rising stage or non-uniform flow in open channels.

LEROY K. SHERMAN, M. Am. Soc. C.E.
President, Randolph-Perkins Company

Chicago, Ill.
June 20, 1933

SOCIETY AFFAIRS

Official and Semi-Official

Society's Sixty-Third Convention A Notable Event

Chicago Outdoes Itself in Technical and Entertainment Program

WARM WAS the welcome and warm was the weather to greet the large throng of members and guests who assembled for Engineers' Week in Chicago, June 26–30. Many organizations of technical and allied interests utilized this place and time, so that the city presented the unusual spectacle of a national engineers' assembly. As a result, it seemed that the profession actually possessed the city, thus accepting the generous and hospitable offer of the Hon. Edward J. Kelly, M. Am. Soc. C.E., Mayor of Chicago, delivered at the opening session on Tuesday morning, June 27.

An Engineer Mayor

His Honor responded to the introduction by W. W. DeBerard, M. Am. Soc. C.E., President of the Illinois Section, with an evident feeling of pride in greeting his own society on such an auspicious occasion. After replying to the Mayor's greeting, President Hammond delivered the annual presidential address, taking as his topic "A Century of Civil Engineering in the United States." Also at this session the prizes given by the Illinois Section to members of Student Chapters in its vicinity were bestowed. These young men, from Armour Institute of Technology, Lewis Institute, Northwestern University, Purdue University, Rose Polytechnic Institute, and the University of Illinois, were presented to the meeting and given an enthusiastic greeting. They were accorded the privilege of applying for Junior membership in the Society at the Section's expense.

The afternoon session had as its topic various phases of tax reduction, which were presented by a number of experts from different localities. It was evident that the subject and treatment were of interest, since the subject was treated as in a forum and the discussion was prolonged by members from the floor. This meeting, like that of the morning, was a gathering of the Society as a whole.

In the evening the Society joined with other groups in a general session to hear an address on the "Development of Industry and Engineering During the Century," by Dr. A. P. M. Fleming, a distinguished British engineer. This meeting was conducted under the auspices of the American Association for the Advancement of Science.

Enjoying a Day at the Exhibition

As a special favor to visitors, no technical meetings were scheduled for Wednesday, so that the whole day was given over to attendance at the Century of Progress Exhibition. The opening affair of this eventful day was held at spacious Soldiers Field. There the third presentation of the Guggenheim Medal, an international distinction in aeronautics, was made to Juan de la Cierva. Señor de la Cierva, a civil engineering graduate of the University of Madrid, was cited for his unusual contribution to flying in the invention of the autogyro. The event was a colorful one. An army detachment and band were in attendance. To the accompaniment of a martial air from a bugle and drum corps, the "windmill plane" conveying the medalist and his party came to a graceful landing within the stadium itself, immediately adjacent to the speaker's platform. There the medal was awarded and graciously acknowledged.

Thereafter the large gathering broke up into individual groups. Throughout the day parties of engineers and their families strolled or were conveyed by bus, jinrikisha, or launch, through the immense grounds. The time was all too short, especially for the many who hastened back to the joint engineering dinner, arranged by the Western Society of Engineers. This was the largest gathering, and therefore one of the most notable, of the entire week. It was held at the Hotel Stevens, whereas practically all the other events in which the Society participated were at the Palmer House, which was also the headquarters of the American Society of Mechanical Engineers.

Joint Meetings Create Interest

This combined occupancy, so to speak, was especially convenient for some of the sessions scheduled for Thursday and Friday, which were held as joint meetings. These included, for example, the session of the Applied Mechanics Division of the American Society of Mechanical Engineers and the Structural Division of the Society; also the meeting of the Hydraulics Division of the American Society of Mechanical Engineers in conjunction with the Power Division of the Society. The last-mentioned session, in discussing the St. Lawrence River development, also included the American Institute of Electrical Engineers. This particular topic aroused a good deal of interest.

A wide variety of subjects, both practical and theoretical, local and national, held the interest of members in these simultaneous meetings. So many of the Divisions were represented that a choice among them was a matter of individual taste and often not an easy one. A wide selection of subject matter was available, distributed among the meetings of the Power, Construction, Waterways, Structural, Highway, Surveying and Mapping, City Planning, and Sanitary Engineering Divisions. Most of these held at least two sessions, and some, as many as four.

Between the morning and afternoon sessions, the time was utilized for lunch gatherings. Luncheon on Thursday was in honor of Lytle Brown, M. Am. Soc. C.E., for which event the Society of American Military Engineers stood sponsor.

Over the Bounding Deep

Still another joint event should be mentioned—the boat trip on Lake Michigan, which took place Thursday evening. Held at the close of a torrid day, it afforded a welcome respite. Although a downpour caught some of the party on their way to the dock, it could not dampen their enthusiasm and enjoyment. As the clouds broke and the lights of the Exposition came on, the picture was one to be long remembered.

For the final event of the Convention, another joint meeting was arranged, featuring the subject of economic recovery and the engineer's relation to it. This evening session, also at the Palmer House, was arranged by the sponsor engineering societies, associated with still another group, the Econometric Society. It was held on Friday evening and brought the Sixty-third Annual Convention to a close.

Any such group of joint meetings involving national bodies calls for endless cooperation in order that the various events and interests may harmonize to the best advantage. In Chicago a fortunate combination was available, and the results testified to the fine team work that had preceded. Credit is largely due to the Illinois Section of the Society and the Western Society of Engineers. The Ladies' Committee was also much in evidence and did an excellent piece of work. Teas, luncheons, drives, and inspection tours followed in rapid succession, and the visiting ladies were amply entertained.

Sessions Draw Large Throngs

Allusion has been made to the temperature, which indeed was a source of universal comment. The hottest June in Chicago history came to a climax during Engineers' Week, with its most sizzling day. Fortunately, as if by special order, the day spent in the open at the fair—that is, Wednesday—was one of the mildest of the entire period.

Before and after the meetings, the Century of Progress Exposition came in for a large share of attention. That the visitors devoted so much time to the technical events in spite of such counter attractions speaks volumes for the quality of the technical program.

Approximate counts were made of the members in attendance. The following is listed for the record.

Total registration	1,000
General sessions, Tuesday:	
Morning	300
Afternoon	125
Evening	250
Engineering dinner, Wednesday evening	1,450
Luncheon in honor of Maj.-Gen. Lytle Brown	250
Technical Division meetings:	
Power, Thursday morning	75
Power, Thursday afternoon	300
Power, Friday morning	90
Power, Friday afternoon	40
Structural, Thursday morning	125
Structural, Thursday afternoon	125
Structural, Friday morning	100
Structural, Friday afternoon	100
Waterways, Thursday morning	35
Construction, Thursday morning	50
Construction, Thursday afternoon	75
Highway, Thursday afternoon	30
Surveying and Mapping, Thursday afternoon	35
Surveying and Mapping, Friday morning	35
Sanitary Engineering, Friday morning	75
Sanitary Engineering, Friday afternoon	60
City Planning, Friday morning	35
City Planning, Friday afternoon	30
Boat Trip, Thursday evening	1,000
Joint meeting, Friday evening	300

Aside from the excellence of the program and local arrangements, the meetings were especially notable for the fine spirit of professional sociability and kinship with other societies. This extended even to the travel arrangements, including special trains for engineers from the East on the Baltimore and Ohio Railway. The Society for the Promotion of Engineering Education also contributed of its membership when its own sessions permitted. Members from as far even as the Pacific Coast added to the numbers in attendance. It may indeed be said that no branch of engineering, no field of specialized effort, and no section of the country, lacked its particular share in, and contribution to, the success of the Chicago Convention.

Meeting of the Board of Direction—Secretary's Abstract

ON JUNE 25 and 26, 1933, the Board of Direction met at the Palmer House, in Chicago, Ill., at the time of the Annual Convention, as required by the Constitution; with President Alonzo J. Hammond in the chair; and present George T. Seabury, Secretary; Otis E. Hovey, Treasurer; and Messrs. Black, Buck, Crocker, Enger, Gregory, Henny, Herrmann, Hoffmann, Holleran, Horner, Jonah, Lupfer, Mead, Mendenhall, Morse, Noyes, Perry, Reed, Riggs, Sherman, Stevens, and Tuttle.

Approval of Minutes of Board

The minutes of the meetings of the Board held on January 16 and 17, January 19, and May 12, 1933, were approved.

Approval of Minutes of Executive Committee

The minutes of the meeting of the Executive Committee held on May 12, 1933, were approved and the actions outlined therein were adopted as the actions of the Board, with the exception of certain recommendations that were considered separately.

Members in Arrears

As recommended by the Executive Committee, a certain procedure was adopted in regard to members in arrears of dues, looking toward leniency of treatment.

Reconsideration of the Budget

Reductions in allotments made by the Executive Committee in the budget were reviewed, and, it being recognized that these reductions were not sufficient to meet requirements, further reductions were made, including the abandonment, solely for financial reasons, of the proposed 1933 Fall Meeting, scheduled for Phoenix, Ariz., next October.

Special Committee on Irrigation Hydraulics to Be Discharged December 31, 1933

At the suggestion of the chairman and secretary of the Committee on Irrigation Hydraulics, it was decided to discharge the committee, this action to become effective December 31, 1933. A vote of thanks to the committee for its work was adopted by the Board.

Special Committee on Steel Column Research

The Special Committee on Steel Column Research was discharged with a vote of thanks for its work. The final report of the committee is now being prepared for publication in the next volume of TRANSACTIONS.

Construction League of the United States

As a member-organization, the approval of the Society was given to four applications for membership in the Construction League of the United States.

Engineers Council for Professional Development

The Charter and Rules of Procedure of the Engineers Council for Professional Development were ratified as submitted by the Conference on Certification, made up of representatives of the four Founder Societies, the American Institute of Chemical Engineers, the Society for the Promotion of Engineering Education, and the National Council of State Boards of Engineering Examiners. The Society is represented by J. Vipond Davies and Harrison P. Eddy, Members Am. Soc. C.E., and Charles F. Loweth, Past-President Am. Soc. C.E.

Kansas City Section

Approval was given to an amendment to the by-laws of the Kansas City Section, reducing the dues of Juniors.

Calendar Simplification

A vote by show of hands resulted in the adoption of the following resolutions favoring calendar simplification:

"*Resolved* that the American Society of Civil Engineers, in view of its resolution adopted in 1929 in favor of improving the calendar, notes with satisfaction that in 1931 an international conference of the League of Nations (Fourth General Conference on Communications and Transit), in which the United States Government participated, officially considered this question, and that the conference, although it decided that the time was not then favorable to proceed with a change, recognized that the simplification of the calendar was certainly desirable, and gave to the governments a survey of the question for their future decision.

"*Resolved* that the Society is of the opinion that further steps to secure this much needed improvement in our measure of time, especially from the economic standpoint, should no longer be delayed, and expressed the hope that the League of Nations will not let the opportunity pass to invite the governments to a further consideration of this question at the next meeting of that same conference in 1935 with a view to conclusive action.

"*Resolved* that the Society call the attention of our government to this resolution and express to the Secretary of State the hope that our government will indicate to the League of Nations a desire to have this question again taken up at this conference and to again participate in the discussion.

"*Resolved* that the Society is of the opinion that a reform based on a division of the year into 13 equal months would best adjust the calendar to modern conditions."

Coordination Committee

The subject of a thorough discussion by the members of the Board was the report from the Coordination Committee, which was received and considered by the Executive Committee at its meeting on May 12, 1933, and referred to the Board, together with an explanatory statement subsequently received from the chairman of the Coordination Committee, and also a report from the committee of the Board appointed to give consideration to the Society's relationship with the American Engineering Council.

This latter committee, consisting of Charles H. Stevens, Henry R. Buck, and Leslie G. Holleran, Members Am. Soc. C.E., was discharged with thanks, and the President was empowered to appoint a committee of five members of the Board to study all features of the possibility of coordinating the various joint activities of the Founder Societies into one central agency, the committee to have instructions to communicate with the other national societies, either through similar committees or through other channels, and bring in a report at the next meeting of the Board.

Committee on Professional Conduct

The Committee on Professional Conduct reported on five specific cases presented to it for consideration, action thereon resulting in the acceptance of the resignation of a member; the request that another member resign; and the dismissal of certain other charges.

Secretary, Treasurer, and Assistant Treasurer Reappointed

In accordance with the By-Laws, the Board appointed a Secretary, Treasurer, and Assistant Treasurer. The present incumbents were reappointed as follows: Secretary, George T. Seabury; Treasurer, Otis E. Hovey; Assistant Treasurer, Ralph R. Rumery.

Two New Student Chapters

Approval was given to the organization of two Student Chapters, one at the South Dakota State College and another at Lewis Institute, Chicago, making a total of 108 Student Chapters.

Committee on Salaries

As featured elsewhere in this issue, a report was received from the Committee on Salaries, of which E. P. Goodrich, M. Am. Soc. C.E., is chairman, together with a chart providing diagrammatically a formula defining "Engineers' Minimum Salaries Appropriate to 1933."

Secretary to Use Efforts to Have Engineers Recognized in Reforestation Work

It was pointed out that in connection with the reforestation work authorized by Congress, engineers should be used, recognized as such, and given adequate compensation. The Secretary was authorized to use his efforts in this direction.

Restoration of Employment to Engineers

The following resolution was unanimously carried:

"WHEREAS the condition of the times has necessitated much extra work and time in contacting with the various agencies related to the restoration of employment to engineers, and whereas the Secretary has given freely of his time at unusual expenditure of his energy; therefore be it

"*Resolved* that the Board of Direction of the American Society of Civil Engineers hereby takes occasion to express its appreciation of his devotion to that work."

Administrative Details

The Board devoted considerable time to administrative details, including consideration of reports from its Standing Committees.

Adjournment

The Board adjourned to meet in Chicago, Ill., on September 25, 1933.

Fall Meeting Not to Be Held in 1933

WHETHER OR NOT to hold the projected Fall Meeting of the Society at Phoenix, Ariz., next October presented a difficult problem for solution by the Board of Direction at its Chicago meeting. On the one hand there was the desire that the Society should visit that vicinity and accept the hospitality of the local members; also the knowledge that many preliminary plans had been made and anticipatory interest aroused. But the other side of the picture likewise could not be ignored, including the probability that attendance would be only moderate and the certainty that the expense would be disproportionately large.

It was this last feature which was responsible for the final decision to forego the projected Phoenix meeting. The expenditure involved was not the only item in the Society budget that had to be cut, but it was the largest one. In accordance with this decision, the next meeting of the Society will be in January 1934; the regular Annual Meeting in New York.

Applications for Loans for Public Works

FEDERAL ADMINISTRATOR ISSUES OFFICIAL FORM NO. 1

For use in all applications for public works loans under the National Industrial Recovery Act, the Federal Emergency Administrator of Public Works has now issued "Form No 1." This is of interest to all engineers as indicating the first prescribed step in anticipation of a loan. In order to indicate the data required, Form No. 1 is here given complete as to substance, although not as to format. For actual use, applicants are obliged to secure the official four-page blanks from the Federal Adminstrator.

Form No. 1
FEDERAL EMERGENCY ADMINISTRATION
OF PUBLIC WORKS

State.....

Project No.....
(Not to be filled in)

FEDERAL EMERGENCY ADMINISTRATION OF PUBLIC WORKS

INTERIOR DEPARTMENT BUILDING
WASHINGTON, D.C.

APPLICATIONS FOR LOANS

IF THE STATE ADMINISTRATOR HAS NOT BEEN APPOINTED, HOLD APPLICATION UNTIL APPOINTMENT IS MADE.

(See instructions on last page of this form)

ADMINISTRATOR, FEDERAL EMERGENCY ADMINISTRATION OF PUBLIC WORKS,

THROUGH STATE ADMINISTRATOR AT.....

.....(Note 1)
(Address)

SIR:

1. Application is hereby made by.....

of....., for the approval of the project
(Address)

herein described, and for allocation by the United States of the sum of.....

.....dollars ($.....) to provide for its construction

under the provisions of Sections 202 and /or 203, 206, 207, and 208; National Industrial Recovery Act, approved June 16, 1933.

2. Legal authority, and identity of the applicant. (See Note 2.)

3. Description of work proposed. (Attach a general plan, see Note 3.)

a. Character of project. (See Note 4.).....

b. Has work been started?.....

c. Are construction plans ready now?.....

If not, when will they be ready?.....

d. State length of time required after approval before construction work can commence?.....

e. How long will it take to complete construction?.....

f. Is the project part of a larger plan or program?.....

g. Is approval by Federal, State, or Municipal authorities required? (See Note 5.).....

If so, what steps have been taken to secure approval?.....

4. a. Estimated total cost: $..... (See Note 6.)

(1) Construction work, exclusive of cost of land.

(a) Labor, $.....

(b) Material, $.....

(c) Engineering and overhead, $.....

(d) Interest during construction, $.....

(2) Cost of land, if any, required for project, $.....

b. Estimated expenditures by months after commencement of construction.....

5. Financial status of applicant

a. For States and Municipalities, or other Public Bodies:

(1) What is present total bonded indebtedness of applicant?.....

(2) Are there overlapping debts on this project?.....

(3) What is limit of bonded indebtedness of applicant authorized by law?.....; per cent of assessed valuation?.....
(Amount in dollars)

(4) What authority has applicant to issue bonds or other securities for this work?.....

(5) Is the budget of the applicant balanced?..... If not, what steps are being taken to balance it?.....

Attach complete financial statement for latest fiscal year, and a statement showing receipts and expenditures for the four years preceding.

(6) What percentage of taxes is now delinquent, and how long outstanding?.....

6. Brief statement covering—

a. Necessity or convenience of the project—has it been approved locally?.....

b. How approved?.....

c. What general classes of labor or construction personnel will it benefit?..... How many man-hours required?....

d. Brief general description of project and any additional pertinent information to be attached.

7. REMARKS:.....

.....
(Official title)

INSTRUCTIONS TO APPLICANT

NOTE 1. *To whom application should be presented.*

The application and the papers and plans accompanying it should be submitted to the State Administrator, Federal Emergency Administration of Public Works, whose office is situated in the State in which your project is located.

The application and all papers accompanying it will be submitted in quadruplicate.

NOTE 2. *Authority and identity of applicant.*

If the applicant is a corporation, copies of the following papers, all properly authenticated, must be furnished:

The charter of articles of incorporation.
The minutes authorizing project.
Extracts from minutes showing names of existing officers of the corporation.

In cases of applications by State or political subdivisions: Where State and/or local laws vest in State or municipal officers, such as State Engineer, Board of Public Works, etc., the power to construct projects, proceedings of the boards, etc., and/or certified extracts from the laws must be furnished which will readily establish the legal authority of the applicant to undertake the project. Applicants will expedite matters if an approving legal opinion of local counsel accompanies the application.

NOTE 3. *Drawings.*

By general plan is meant a drawing showing general location, plan, profile and character.

As few sheets will be used as necessary, to show clearly the general features only and the location of the project. Detailed plans are not desired at this time.

The scale will be shown graphically. The north and south line will be indicated by a meridian arrow.

NOTE 4. *Character of project.*

State in general terms the general character of the work proposed, for example: "Extension of water works," or "construction of incinerator," etc.

NOTE 5.

Approval by Federal, State, or Municipal authorities is required in certain types of projects; for example, before construction of a bridge over a navigable waterway is undertaken, approval by the Secretary of War and the Chief of Engineers is required.

NOTE 6. *Estimated cost.*

This must be based on the special conditions prescribed in the Act, particularly Section 206. The rate of interest during construction will be announced later.

THERE IS NO CHARGE FOR FILING THIS APPLICATION

Paper Bound "Transactions" to Be Issued

ENCOURAGED by the economy secured by issuing the 1933 *Year Book* as Part 2 of the April PROCEEDINGS, the Publications Committee has recently instituted inquiries regarding a similar treatment of TRANSACTIONS. The great saving by this plan is because of the second class postal privileges accorded to PROCEEDINGS.

The U.S. Post Office Department has agreed to the necessary classification as far as the paper bound copies of TRANSACTIONS are concerned. Accordingly these will be mailed under the same cover as PROCEEDINGS. As for the cloth and morocco bindings, the regulations are prohibitive, so that these must be mailed as in the past, subject to fourth class postal rates.

Under present plans it is contemplated that "TRANSACTIONS Number 97" in paper will be issued as a separate part of PROCEEDINGS. This volume contains the papers and discussions covering all the engineering plans of the George Washington Bridge. The regular TRANSACTIONS for the year will then be Number 98 and will be published and mailed in the same way, as a part of some number of PROCEEDINGS. It is possible that the cloth and morocco editions of these volumes may go out together, as soon as the bindings are ready, say, by November 1.

Student Chapters Are Not Honor Societies

MORE THAN ONCE the question has arisen as to whether it is permissible to organize Student Chapters of the Society as honor groups in their colleges. Recently, when the question cropped up again, the Committee on Student Chapters reaffirmed its previous decision, which was against such practice. Standards for admission to Student Chapters are high, and should be uniform, but the committee does not feel it is desirable for any Chapter to set up special discriminatory rules. In this view the Board of Direction has concurred.

Appointments of Society Representatives

ALONZO J. HAMMOND, President Am. Soc. C.E., was appointed one of the Society's four representatives on the John Fritz Medal Board of Award for the four-year term beginning in October 1933.

LANGDON PEARSE, THORNDIKE SAVILLE, and ABEL WOLMAN, Members Am. Soc. C.E., have been appointed to serve as the Society's representatives on a Joint Committee of the Society and the American Institute of Chemical Engineers on Water Pollution.

FRANK A. RANDALL, M. Am. Soc. C.E., and W. C. E. BECKER and VAN TUYL BOUGHTON, Associate Members Am. Soc. C.E., have been appointed Society representatives on a Joint Committee of the Society and the American Institute of Architects to evolve methods for a better understanding and better cooperation between the engineers and architects.

A Preview of Proceedings

After the usual summer interval, the publication of PROCEEDINGS *is again resumed with the August issue, which will be mailed on August 15. The three main papers deal with the behavior of siphon spillways, the traffic capacity of streets, and an analysis of the three official plans for development of power on the international section of the St. Lawrence River.*

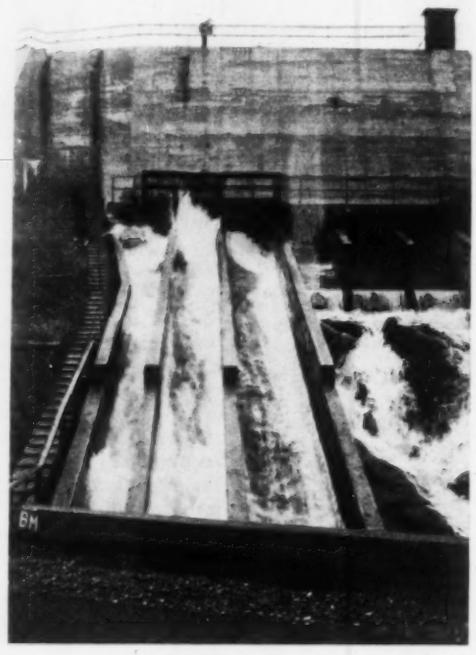
THE BEHAVIOR OF SIPHONS

RESULTS OF TESTS on three siphons having normal capacities of 100, 250, and 500 sec-ft, form the basis of the paper by J. C. Stevens, M. Am. Soc. C.E. These siphons are a part of the Leaburg hydro-electric plant, about 60 miles south and west of Salem, in the State of Oregon. One interesting feature of these tests is the fact that the barrel of the siphon did not flow full except at the throat. A recommendation is made regarding a measure of efficiency of the siphon. Mr. Stevens also presents a nomenclature and a system of notation for use in discussing the theory of flow in siphons.

USE AND CAPACITY OF CITY STREETS

CONSIDERING its significance in the economic welfare of the city, the ability of an urban street system to perform its primary function of transportation is a matter upon which comparatively little information is available. The paper by Hawley S. Simpson, Assoc. M. Am. Soc. C.E., analyzes, in detail, the many phases of this important subject. In arriving at conclusions as to the capacities of city streets, the author considers the retardation of traffic caused by irregular traffic movement, the effect of parking on traffic flow, and the reduction in the vehicle capacities of streets occasioned by mass transportation vehicles.

A number of tables are included showing the capacities, in vehicles, of typical elevated highways and surface streets when used solely by private automobiles, and of surface streets when used jointly by private and mass transportation vehicles, both when parking is prohibited and when it is permitted. From these tables has been developed a schedule of passenger capacities which, in the last analysis, measures most accurately the utility of city thoroughfares. The paper by Mr. Simpson should be of particular interest to municipal engineers charged with the direction of street construction programs and to those concerned with the regulation of street traffic.



SIPHON SPILLWAY OF LEABURG HYDRO-ELECTRIC PLANT
60 Miles Southwest of Salem, Ore.

WATER POWER DEVELOPMENT ON THE ST. LAWRENCE RIVER

AS A DISINTERESTED engineer familiar with water power development, Daniel W. Mead, Hon. M. Am. Soc. C.E., was requested jointly by the executive committees of the Power Division of the Society, the Hydraulics Division of the American Society of Mechanical Engineers, and the Program Committee of the American Institute of Electrical Engineers, to examine the official reports on the water power development of the international section of the St. Lawrence River, and to present his analysis of the comparative values of the three principal plans contained in these reports before a joint meeting, on June 29, 1933, at the Annual Convention of the Society in Chicago.

The plan of development on which the pending treaty is based is the two-stage Crysler Island Plan, advocated by the Canadian members of the Joint Board of Engineers. It is stated by Dr. Mead that this plan not only will have a first cost greater than the single-stage (New York) Massena Point Plan, but also will be deficient in output and earning capacity, and more expensive in cost of operation. The total capitalized credit in favor of the single-stage Massena Point Plan is estimated by him to be at least $140,000,000, an amount great enough to warrant reconsideration of the proposed plans before the treaty is ratified.

A similar invitation was extended to T. H. Hogg, M. Am. Soc. C.E., who presented the Canadian viewpoint in a discussion of Dr. Mead's analysis. To make the estimates of cost of the three plans comparable, Dr. Hogg finds it necessary to add numerous items totaling more than $45,000,000 to the official estimate for the single-stage New York Plan, making it more costly than the single-stage Conference Plan by $13,000,000. However, he contends that the choice between a single-stage and a two-stage plan of development cannot be reached on purely economic or engineering grounds. It involves a consideration of the high-water hazard to communities below the development due to dangerous ice conditions. Canadian public opinion strongly demands adoption of the two-stage plan, in spite of its greater cost, because it would disturb the river communities less than either of the single-stage plans. Both Dr. Mead's analysis and Dr. Hogg's discussion will appear in the August PROCEEDINGS.

Salary Reductions for Civil Engineers

SOCIETY'S COMMITTEE SUGGESTS LIMITS TO BE APPROACHED IN EXTREME CASES

June 21, 1933

TO THE BOARD OF DIRECTION:

The matter of salary cutting during the depression is vital to all engineers, whether as employers or employees. Such cutting has been almost universal over the country, but has been uniform in neither manner nor amount.

On the other hand, it is observed that the suffering resulting from unemployment is now contributing to a movement of large proportions in which men, even of high training, are offering themselves at almost any price. It is believed that the Board of Direction of the Society should assume the obligation of establishing a defensible minimum wage scale in behalf of the members of the profession.

Accordingly, the attached chart has been prepared showing a determination of the limiting salary changes, which, in the light of the very considerable mass of data accumulated by the committee in the past several years, can be considered as legitimate at this time. These limits should not be approached except under extreme conditions.

It will be noted that no suggestion is made beyond $5,000. This is for the reason that salaries above this point are dependent upon a consideration of the size, or importance, or complexity of the job and upon the special qualifications and capacity of the man. Also, the number of men receiving salaries greater than $5,000 is small in comparison with the total number of civil engineers. For all these reasons, such salaries cannot safely be placed in any standarized category.

On the other hand, salaries normally below the $5,000 figure are those which apply to probably 90 or 95 per cent of the civil engineers in the country.

The effort to support salaries of civil engineers is expressed in terms of limiting percentage deductions from the salaries which

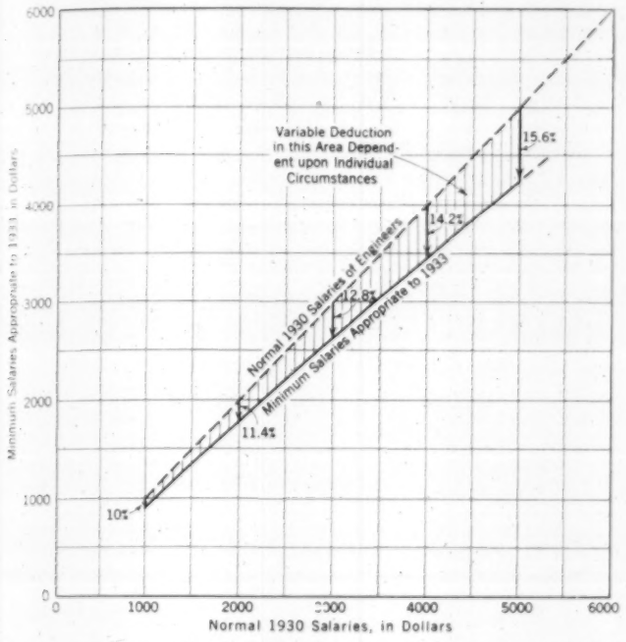


FIG. 1. ENGINEERS' MINIMUM SALARIES APPROPRIATE TO 1933 Subject to Quarterly Revision

were paid in 1930, taking into account the present and then value of the dollar. Being a ratio, it automatically takes care of regional differentials in cost of living and other conditions of employment which obtain for engineers in common with all citizens resident in such regions.

The adoption by the Board of Direction of the recommended scale of permissible salary changes will help materially to prevent a wholesale destruction of the economic value of the technical services of at least the civil engineering portion of the engineering profession.

For the Committee on Salaries

E. P. GOODRICH, *Chairman*

This report, submitted at its Chicago meeting on June 26, 1933, was approved by the Board of Direction and unanimously adopted.

News of Local Sections

ARIZONA SECTION

A meeting of the Arizona Section was called to order on May 13, in the library building of the University of Arizona at Tucson, with members from Phoenix, Nogales, Tucson, and several other towns in attendance. Members of the University of Arizona Student Chapter were also guests of the Section. The meeting was a prolonged business session, beginning in the afternoon and extending into the evening, with an intermission for dinner and a brief musical entertainment. Among the subjects that elicited much discussion were Arizona's flood-control problem and public works. The president of the Section addressed the students, urging them to become members of the Society upon their graduation from the university.

DETROIT SECTION

The June meeting of the Detroit Section was given over entirely to a discussion of the "Trade Recovery Bill." The opening paper on this subject was presented by Clarence Hubbell, consulting engineer of Detroit, and the 16 speakers who followed maintained the interest of the meeting at a high pitch.

GEORGIA SECTION

On June 5 a joint meeting of the Georgia Section of the Society, local chapters of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers, and the Georgia School of Technology Student Chapter was held at the Atlanta Athletic Club. There were 59 present. After luncheon, B. P. McWhorter, State Highway Engineer, and Searcy B. Slack, Bridge Engineer for the State Highway Board, gave talks on highway and bridge problems of local interest.

ITHACA SECTION

On June 15 the Ithaca Section held a dinner meeting at the Kalurah Country Club, Binghampton, N.Y., with 18 members and guests present. The speaker of the evening was E. R. Berk, of Youngstown, Ohio, who gave a stimulating illustrated address on the subject of "Steel Bridge Floors."

KANSAS CITY SECTION

There were 34 in attendance at the dinner and meeting of the Kansas City Section held on June 28 at the Hillcrest Country Club. The work of Juniors was featured, and the principal paper was by L. W. Miller, a Junior who is employed at the U.S. Engineer Office. His subject was "Sedimentary Investigation in the Missouri River." After the discussion which followed, several reels of motion pictures showing the construction of bridges and river control work, including dikes, mattresses, and bank revetments, were shown by Mr. Knerr and Mr. Maitland of the Kansas City Bridge Company.

PHILADELPHIA SECTION

The outing and annual meeting of the Philadelphia Section were held on June 15 at the Pennsylvania Golf Club near Fraser, Pa. In the afternoon members played golf or enjoyed a social hour at the clubhouse. A dinner preceded the meeting in the evening, which marked the completion of the Section's twentieth year. Two of the original members, M. W. Easby and Henry H. Quimby, were present and gave brief talks of a reminiscent nature. During the business session the tellers reported the election of the following officers for the coming year: Sanford W. Sawin, President; Isaac S. Walker, Vice-President; and Charles A. Howland, Secretary-Treasurer.

PORTLAND (ORE.) SECTION

The Portland (Ore.) Section's joint meeting with the Student Chapter of Oregon State College was held on May 20 at Corvallis. A number of interesting events marked the meeting, including a baseball game, a golf tournament, a polo game, and a crew race. These were followed by an inspection of the college's engineering laboratories and by a technical meeting. Dinner was served at the Benton Hotel and was a joint affair, including members and guests of the Northwest Highway Association. It was followed by dancing.

PUERTO RICO SECTION

The quarterly meeting of the Puerto Rico Section was held on June 17. Those present thoroughly enjoyed the papers read by Rafael del Valle on "Practical Vision of New Industries," and by Facundo Bueso on the "Quantum Theory."

SAN FRANCISCO SECTION

A meeting of the San Francisco Section took place at the Engineers' Club on Tuesday evening, April 18, with 101 members and guests present. During dinner, musical entertainment furnished by local talent was enjoyed. After the business session two speakers presented illustrated lectures. These were W. M. Coffey, of the U.S. Corps of Engineers, who spoke on "The Stockton Deep Water Channel—High Lights of Construction"; and W. B. Hogan, City Manager of Stockton, whose subject was "The Purpose and Use of the Stockton Ship Channel." These topics were of considerable local interest.

ITEMS OF INTEREST

Engineering Events in Brief

Civil Engineering for September

IN THE September issue the publication, in shortened form, of the papers read at the Sixty-Third Annual Convention of the Society in Chicago will be completed. That number will contain the papers presented on the last day of the technical sessions, Friday, June 30, 1933, and will include those read before the Structural, Sanitary Engineering, Power, City Planning, and Surveying and Mapping Divisions. Thus the September number, containing abstracts of the papers presented on Friday, and the current number, containing the papers presented on Tuesday and Thursday, together constitute a valuable record of the technical side of the Convention's activities.

Additional Degrees Conferred

INFORMATION recently received at Headquarters adds two names to the list of members of the Society on whom degrees were conferred at commencement time this year. These two additions are:

LEONOR F. LOREE, M. Am. Soc. C.E., Doctor of Engineering, Rensselaer Polytechnic Institute.

DANIEL L. TURNER, M. Am. Soc. C.E., Doctor of Engineering, Rensselaer Polytechnic Institute.

First Concrete in Boulder Dam Poured

AN EVENT of considerable historical significance occurred on June 6, 1933. On that day, in the bottom of the gorge of Black Canyon, 150 ft below the stream bed level, the first concrete was poured in the great dam that is being built by the U.S. Bureau of Reclamation to harness the Colorado River.

Through the courtesy of William Woollett, an artist of Los Angeles, the Society is privileged to reproduce, on the Page of Special Interest in this number, his lithograph of Black Canyon as it appeared in March 1933. It is one of a series made by Mr. Woollett depicting the progress of the construction of Boulder Dam. The viewpoint is just downstream from the lower portals of the diversion tunnels, with the Nevada shore on the left and the Arizona shore on the right. Only two of the four diversion tunnel outlets are visible. The clouds rising from the bottom of the canyon at its further end are dust and smoke from a recent blast in its side walls. Some idea of the grandeur of the setting and the immensity of the work is obtained from this view.

At the present time the four diversion tunnels, each 50 ft in diameter, are carrying the entire flow of the Colorado River while concrete for the dam is being poured in the dry between two earth and rock cofferdams, one above and one below the dam site. Another lithograph by Mr. Woollett, which shows the interior of one of the diversion tunnels, is to be found on page 450.

Lecture Room Equipped for Demonstrations on River Hydraulics

Special Apparatus Used at University in Vienna

By HERBERT H. WHEATON, Assoc. M. Am. Soc. C.E.

FREEMAN SCHOLAR OF THE SOCIETY, 1933

AT THE Technical University in Vienna, Austria, Prof. F. Schaffernak has installed equipment in his lecture room which makes possible actual demonstration to his students of most of the problems of river hydraulics and the river hydraulic laboratory. A channel for the flow of water has been erected between the lecturer and the students. It is divided into two parts of about equal length, one 25 in. high and 8 in. wide with two glass sides, and the other 8 in. high and 36 in. wide with metal sides. This channel, which also acts as a reservoir, rests on a U-shaped concrete beam, supported by the walls of the room. Together with a tank, a pump, and stilling basin, which are in an adjoining room but connected to the channel through the wall, it forms a closed system for the circulation of water.

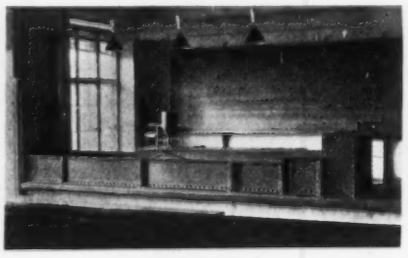
In the glass channel can be shown weirs, spillways, piers, and many other kinds of models, as well as hydraulic phenomena such as the jump and wave motion. Here the operation of current meters and other hydrological equipment is also demonstrated. In the flat metal channel, river problems such as bank and bed erosion, erosion around structures, sand-bank formation, and silt transportation, can be demonstrated.

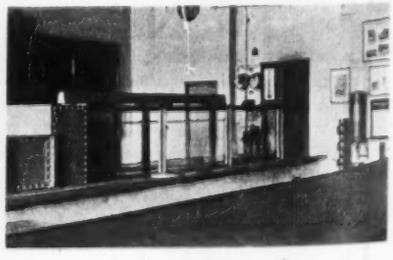
Water is supplied to the system by a pump which can deliver 40 liters per sec. The pump and forebay are in the adjoining room but the pump can be operated and the forebay water level regulated by the lecturer through remote controls. An electrically lighted gage at the intake end of the channel indicates the forebay water level so that it can be seen by the students.

The flow into the glass channel is regulated by an adjustable undershot gate, and water can leave this channel either by an overflow or undershot gate. From the outlet of the first channel the water can be returned to the tank beneath or conducted to the flat metal channel beyond. At the outlet of the metal channel is a sand trap and an adjustable overflow gate. Safety outlets are provided so that overflowing of the sides is impossible.

Emphasis has been laid on good electric lighting so that students anywhere in the room can see the demonstrations clearly. Many pieces of auxiliary apparatus are kept on hand so that all sorts of demonstrations can be made with a minimum of installation work. At the rear of the room is an apparatus for the display of laminar and capillary movement of water in earth and earth-fill dams and levees. A rain gage with electrical recording apparatus and other small instruments complete the equipment.

The lecture room installation of Professor Schaffernak has proved to be so practical that it has been copied in several large universities in various parts of the world. It makes available to the lecturer on hydraulics the type of demonstration equipment almost universal among lecturers in pure science departments but too seldom used by engineers.





LECTURE ROOM EQUIPMENT FOR DEMONSTRATIONS IN HYDRAULICS
Technical University in Vienna, Austria

Earthquake Hazard and Earthquake Protection

Conclusions and Recommendations Resulting from a Study of the Effects of the Long Beach Earthquake

AN EARTHQUAKE SHOCK of moderate magnitude at 5:54 p.m. on March 10, 1933, caused great property damage and severe loss of life at Long Beach, Calif., and in neighboring communities. Immediately thereafter committees of several technical societies and other interested organizations began an investigation of the effects of the quake, the reasons for the loss of life and property damage, and the steps necessary to minimize the effects of such an occurrence in the future. To correlate these efforts, a Joint Technical Committee on Earthquake Protection was formed under the chairmanship of Dr. Robert A. Millikan of the California Institute of Technology.

Although many months of detailed investigation are yet ahead of this committee, the essential conclusions have been made available in an advance summary recently released. The conclusions contained in this summary are quoted verbatim from the report, as follows:

"Certain fundamental conclusions are evidenced by years of geological and seismological investigations in California and other parts of the Pacific Southwest.

"(a) Earthquakes of damaging or destructive intensity will continue to occur in California from time to time in the future.

"(b) An earthquake is apt to occur in this region comparable in intensity and duration with the San Francisco earthquake of 1906.

"(c) The risk of damage or destruction of buildings and other structures, and attendant loss of life, varies somewhat but not greatly throughout this region.

"(d) The degree of risk is such that earthquake resistant construction is absolutely necessary in this region in order to avoid great loss of life and heavy damage to property."

. . . .

"Analysis of the effect of the earthquake of March 10, 1933, leads inevitably to the conclusion that:

"(a) Damage to buildings and other structures and loss of life and injury to persons are not restricted to a narrow strip along a fault zone.

"(b) Structures built on soft ground or in areas of deep alluvium are adversely affected.

"(c) In the areas subjected to intense shock, fireproof skeleton-frame buildings suffered less proportional damage than buildings of the bearing-wall type.

"(d) Well braced wood-frame residences were particularly resistant to the shock, except for the collapse of chimneys.

"(e) All types of structures where cheapness had been the governing factor suffered severely.

"(f) School buildings were generally unable to resist the force of the earthquake where the shocks were at all intense, and all similarly constructed school buildings must be considered incapable of resisting an earthquake of destructive intensity.

"(g) Loss of life was much less than would have been the case if the earthquake had occurred a few hours earlier. Such loss of life and injury to persons as did occur was due largely to falling debris, particularly from parapet walls, cornices, and other ornamentation, and from the outward collapse of poorly supported masonry, tile, and brick walls.

"(h) All buildings should be, and school buildings must be, so re-designed and strengthened that a repetition of the recent disaster cannot take place."

. . . .

RECOMMENDED STANDARDS OF DESIGN

"Except for certain special types of construction, such as well braced wood-frame residences, it is recommended that all existing buildings be brought up to the following standards, and that in the design of all new buildings the following should be considered the minimum standards:

"(a) Horizontal Forces. In the design of buildings, and all other types of structures which extend above the surface of the ground, a horizontal force of at least one-tenth that due to gravity, that is, one-tenth of the superincumbent weight, should be assumed. Special structures and parts of structures, such as tanks, towers, chimneys, smokestacks, pent houses, etc., should be designed to resist a horizontal force of not less than one-fifth of their weight. All fire walls, parapet walls, and other similar walls, and all exterior ornaments and appendages, should be designed to resist a horizontal force equal to the full weight of such walls, ornaments, or appendages.

"(b) Live Loads. The live loads to be used in designs for earthquake protection should be not less than one-half the live loads used in design of buildings, bridges, and other structures for vertical forces, except that no reduction in live load should be made in the case of warehouses and other structures normally subjected to full live loads.

"(c) Combined Stresses. The combined stresses due to vertical and horizontal forces should not exceed by more than one-third the maximum unit stress allowed in designs for vertical forces only. Such combined stress should in no case be more than one-half of the ultimate strength of any material of construction in compression, tension, or shear."

. . . .

"Compared to the large number of buildings which now exist in this metropolitan center and in other communities throughout the Pacific Southwest, relatively few new buildings will be constructed during the next ten years; consequently the necessity for strengthening existing buildings is more important even than a change in the standards for new buildings. In so far as the police power of the state will permit, it should be required that all privately owned existing buildings be made earthquake resistant. Strengthening of public buildings, however, is subject to the will of the people, and there should be no delay in making these buildings, particularly school buildings, safe."

. . . .

"For the average urban community it may be assumed that a sum equal to 25 per cent of the original cost of all school buildings will be required directly and indirectly to make these buildings reasonably safe in the event of an earthquake. To the actual cost of all new work and reconstruction must be added special costs of investigation and in many cases a large sum for temporary housing of children. While the cost of school buildings in California averages approximately $50 per capita, the investment in such buildings in communities where major structures are general, probably is closer to $60 per capita; consequently it should be anticipated that about $15 per capita may be required to meet the cost of making the schools safe. In the aggregate, the expenditure therefore will be large, but the question should be only how can the necessary funds be provided."

. . . .

"It must be recognized that earthquakes of more than moderate magnitude may occur at any time in this region, that a severe conflagration might follow such an earthquake, and that as a result the damage might be increased tenfold. It is therefore very important that:

"(a) Buildings and other structures should be designed and constructed or strengthened so as to be capable of resisting earthquake forces.

"(b) Buildings should be made as nearly fireproof as practicable, and all buildings in congested districts should be fire-resistant to a greater degree than is now required.

"(c) A major disaster plan should be worked out in each area with the same care and high degree of organization as the plan which has been developed in Los Angeles under the guidance of the Fire Department."

Members of the Society who have been active in the conduct of the investigation and preparation of the report are: R. R. Martel, Vice-Chairman; Raymond A. Hill and R. V. Labarre, representing the Los Angeles Section; Oliver G. Bowen and Blaine Noice, representing the Structural Engineers Association of Southern California; and Ralph J. Reed, representing the Los Angeles Engineering Council of Founder Societies.

1930 Census on Construction

A STUDY of the location and the agencies of the construction industry in the United States, based on the 1930 Census, has been issued by the Bureau of the Census. Some of the most interesting phases of the analysis are the following: comparability of projected totals with existing statistics of construction contracts

awarded and building permits issued; the problem of outside competition; distribution of construction work throughout the United States, per square mile and per capita; and the actual value of construction in each state, according to the location of the executive offices of the organizations that carried out the work.

Copies of this report, "Construction in the United States: A Study of Its Location and Agencies," can be secured on request from the Superintendent of Documents, Washington, D.C., for the price of 10 cents.

Engineers for Public Building Program

PRIVATE ENGINEERS and architects throughout the country will be engaged by the Treasury Department to prepare the plans and specifications for a large Federal building program, which may reach a total of $200,000,000. L. W. Robert, Jr., M. Am. Soc. C.E., Assistant Secretary of the Treasury, has adopted this policy in order that professional men who have not had employment will benefit by the large expenditure for new Federal buildings, the design and construction of which come under the authority of the Supervising Architect's Office of the Treasury.

For the purpose of spreading employment as far as possible among engineers and architects who, preferably, have had some previous experience in public building work, Mr. Robert has requested the cooperation of the American Engineering Council and the American Institute of Architects in enrolling qualified individuals and firms. His purpose is to engage on every building engineers and architects resident in the state in which it will be erected.

The Treasury Department, with the cooperation of the American Institute of Architects, is asembling the records of architects throughout the country. Each known architect has or will receive a prequalification blank, which should be forwarded to reach the Treasury Department promptly.

As the procedure adopted for enrolling architects could not be utilized satisfactorily to obtain the same character of information concerning engineers, the American Engineering Council has been requested by Mr. Robert to compile state lists of engineers and engineering firms that customarily engage in construction of buildings of the monumental character usually typifying those built by the Federal Government.

Through its member organizations and other technical groups, the Council inaugurated its canvass several weeks ago. The lists are being prepared so that the Council will be in a position to submit to the Treasury Department the names of competent engineers in any and all states when there is a call for the services which they are qualified to render. Any qualified engineer desiring to participate in the Treasury Department's building program should send to L. W. Wallace, Executive Secretary, American Engineering Council, 744 Jackson Place, N.W., Washington, D.C., a complete statement, in duplicate, of his professional record, with a citation of significant references.

The function of the American Engineering Council in enrolling engineers for the building program is to make available lists of competent engineers and firms and not to select and employ men. These are functions of the Treasury Department.

The American Engineering Council is gladly cooperating with Assistant Secretary of the Treasury, Mr. Robert, and the American Institute of Architects in making available to private engineers and architects construction work done under the direction of the Supervising Architect's Office.

Argentinian Engineers Find Society Publications Useful

THE REPORT of the Society's Special Committee on Irrigation Hydraulics, entitled "Standard Symbols and Glossary for Hydraulics and Irrigation," was published in the May 1932 issue of PROCEEDINGS. Students of engineering at the University of Buenos Aires found this glossary so useful in translating and interpreting the vast amount of technical literature in English on the subject of irrigation and hydraulics that steps were taken to make a Spanish translation of it.

With the cooperation of the engineering students and the collaboration of the engineers of the Irrigation Department of the Argentine Federal Government, the translation was made by Rodolfo E. Ballester, Professor of Applied Hydraulics at the university. It has been published in monograph form with a suitable foreword. The task of translating the glossary and finding equivalents for the different terms that are used where Spanish is spoken, was not an easy one, but it is hoped that the effort will be repaid by making English literature on hydraulics more accessible.

NEWS OF ENGINEERS

From Correspondence and Society Files

GEORGE P. STOWITTS announces the opening of an office in Cincinnati, Ohio, for general practice as a civil and consulting engineer. He was previously Engineer of Construction for the Cincinnati Union Terminal Company, of the same city.

C. M. DAILY has received an appointment as Water Commissioner of the City of St. Louis, Mo. He was formerly Vice-President and Chief Engineer of the Missouri Engineering and Contracting Company, of the same city.

JOHN K. FLICK has resigned his connection with the Inter-American Highway, Balboa, C.Z., to accept a position with the U.S. Bureau of Public Roads, in Washington, D.C.

M. C. NOBLE has accepted a position with the W. Q. O'Neall Company of Springfield, Ill., as general manager.

J. C. OBLAN, who has for some time been engaged in engineering work for the U.S.S.R., has now been made Chief Engineer of the Giprostalmost (State Institute for the Design of Steel Structures), with headquarters in Moscow.

JERMAIN CHANDLER, formerly Assistant Chief Engineer of the Donovan Wire and Iron Company, has established a consulting engineering practice in Toledo, Ohio, specializing in mechanical development work.

ANSON W. ROHLWING has accepted employment as Field Engineer for the Portland Cement Association, with headquarters at Louisville, Ky.

FEDERICO DAVILA has resumed his connection with the Engineering Department of the Lago Petroleum Corporation, of Maracaibo, Venezuela. He is engaged as Field Engineer at the Lagunillas oil field.

E. R. KINSEY, who recently completed his twentieth year as President of the Board of Public Service of the City of St. Louis, Mo., announces that he has established a consulting engineering practice at 1931 Railway Exchange Building, St. Louis.

A. CHARLES WAGHORNE and MAURICE F. BROWN announce the formation of a general partnership under the firm name of Waghorne-Brown Company, with offices in the Waterman Building, 44 School Street, Boston, Mass. Mr. Waghorne was formerly Vice-President of the Palmer Steel Company, of Springfield, Mass., while Mr. Brown was a member of the firm, Harty and Brown, of Boston.

KARL B. KUMPE has been made President of the Kumpe-Hauser Corporation, Ltd., of Long Beach, Calif. He also retains the position of Vice-President of the Hauser Construction Company, of the same city.

J. W. PFAU, Assistant Chief Engineer of the New York Central Railroad (Buffalo and East), has been appointed Acting Chief Engineer, in place of F. B. Freeman, who has been furloughed on account of ill health.

H. P. BUNGER, formerly Designing Engineer for the J. G. White Engineering Corporation, City of Mexico, has now accepted employment with the Middle Rio Grande Conservancy District, with headquarters in Albuquerque, N.Mex.

CHIEN HSU has accepted a connection with the Train Ferry Construction Bureau, Ministry of Railways, Nanking, China. He was formerly Assistant Professor of Civil Engineering in Tsing Hua University, at Peiping, China.

Changes in Membership Grades

Additions, Transfers, Reinstatements, Deaths, and Resignations

From June 10 to July 9, 1933, Inclusive

Additions to Membership

Boddington, Norman, Capt., R.E. (Assoc. M. '33), Barford St. Michael, Oxford, England.

Boyd, George Edward (Assoc. M. '32), Sales Engr. and New York Dist. Mgr., Wailes Dove Hermiston Corporation, 17 Battery Pl., Room 1737, New York, N.Y.

Brown, William Thurman (Jun. '33), Asst. Constr. Engr., Treasury Dept., U.S. Govt., New Post Office Bldg., Orono, Me.

Cashen, Robert Leo (Assoc. M., '33), Asst. Engr., Atmospheric Nitrogen Corporation, Box 6, Hopewell, Va.

Digges, Edward William (Assoc. M. '32), Asst. Engr., U.S.A. Engrs., U.S. Engr. Suboffice, Clewiston, Fla.

Frohboese, Ernest William (Jun. '32), 65 North Maple Ave., East Orange, N.J.

Gallagher, William Joseph (Jun. '32), Engr., Blunk & Joehnke (Res., 913 Grand Ave.), Davenport, Iowa.

La Rosée, Paul Henri (Assoc. M. '33), Care, Safe Harbor Water Power Corporation, Safe Harbor, Pa.

Powell, William Llewellyn (Jun. '33), Cons. Engr. (Wood, Powell & Powell), 2022 Republic Bank Bldg., Dallas, Tex.

Shahan, Maxwell Lee (Jun. '32), 930 Oak St., Chattanooga, Tenn.

Skerrett-Landron, Ricardo (M. '33), Asst. Chf. of Div., Dept. of the Interior, Govt. of Puerto Rico (10 Hernández St.), Santurce, Puerto Rico.

Taylor, Byron Kizer (Assoc. M. '33), Asst. Engr. (Civ.) Eugene Water Board (Res., 31 East 15th St.), Eugene, Ore.

Taylor, Oliver Guy (M. '33), Asst. Chf. Engr., National Park Service, Washington, D.C. (Res., 6313 Georgia St., Chevy Chase, Md.)

Wilson, Milton Theurer (Assoc. M. '33), Asst. Engr., Water Resources Branch, U.S. Geological Survey, 303 Custom House, San Francisco, Calif.

Membership Transfers

Amberg, Gustav Adolf (Jun. '23; Assoc. M. '33), Pres., G. A. Amberg Co., Inc., 1201 Cotton Exchange Bldg., Memphis, Tenn.

Barrekette, Abraham Eliezer (Jun. '25; Assoc. M. '33), Engr. and Contr., Care, The New British Drug Co., Jerusalem, Palestine.

Campbell, Benjamin Lucien (Assoc. M. '31; M. '33), 7100 South West Brier Pl., Portland, Ore.

Norris, Robert (Assoc. M. '17; M. '32), Hydr. and Elec. Engr., Ayres, Lewis, Norris & May, Cornwell Bldg., Ann Arbor, Mich.

Resignations

Chambers, Bernard Isbister, M., resigned July 5, 1933.

Deaths

Blue, Frederick Kellogg. Elected M., Nov. 21, 1921; died May 31, 1933.

Butler, Matthew Joseph. Elected M., April 1, 1885; died June 22, 1933.

Drabkin, Abraham Leonard. Elected Assoc. M., June 4, 1928; date of death unknown.

Easterbrook, Frederick James. Elected M., May 3, 1905; died March 30, 1933.

Louwerse, Peter Martin. Elected Assoc. M., April 1, 1908; died May 25, 1933.

Mason, Arthur John. Elected M., Sept. 5, 1888; died June 28, 1933.

Miller, Edward Furber. Elected M., June 3, 1903; died June 12, 1933.

Moir, Sir Ernest William. Elected M., Sept. 7, 1904; died June 15, 1933.

Reich, Philip Jacob. Elected Assoc. M., June 5, 1907; M., Dec. 5, 1911; died May 31, 1933.

Rodezno, Rafael. Elected Assoc. M., Sept. 10, 1923; died March 17, 1933.

Rowe, Berney Elgin. Elected Assoc. M., Nov. 9, 1920; died January 1933.

Shankland, Ralph Martin. Elected M., Mar. 1, 1899; died June 28, 1933.

Sloan, David. Elected M., Jan. 1, 1896; died June 25, 1933.

Warnock, William Harold. Elected Jun., Apr. 4, 1911; Assoc. M., Oct. 29, 1912; died June 17, 1933.

West, Charles Hunter. Elected, M., Oct. 1, 1902; died June 7, 1933.

Wilcock, Frederick. Elected Jun., Jan. 7, 1902; Affiliate, Oct. 6, 1903; Assoc. M., Jan. 4, 1910; M., June 16, 1924; died June 15, 1933.

TOTAL MEMBERSHIP AS OF JULY 9, 1933

Members	5,786
Associate Members	6,317
Corporate Members	12,103
Honorary Members	18
Juniors	2,962
Affiliates	113
Fellows	5
Total	15,201

Men Available

These items are from information furnished by the Engineering Societies Employment Service, with offices in Chicago, New York, and San Francisco. The Service is available to all members of the contributing societies. A complete statement of the procedure, the location of offices, and the fee is to be found on page 97 of the 1933 Year Book of the Society. To expedite publication, notices should be sent direct to the Employment Service, 31 West 39th Street, New York, N.Y. Employers should address replies to the key number, care of the New York Office, unless the word Chicago or San Francisco follows the key number, when the reply should be sent to the office designated.

Construction

Civil Engineer; Jun. Am. Soc. C.E.; single; B.S. in C.E.; licensed professional engineer, Puerto Rico; neat, ambitious; speaks Spanish fluently, also English and French; 6 years experience as instrumentman, highway and canal surveying, topographical draftsman, surveyor, resident engineer on highway and house construction. Willing to travel. Available immediately. Salary secondary. D-2247.

Sanitary Engineer; Assoc. M. Am. Soc. C.E., Member A.W.W.A. and Penn. Sew. Works Assn.; 38; married; Cornell graduate; experienced in all phases of water-works and sewerage design and construction; has been connected with at least thirty water-works and sewerage projects; active student; can handle design or construction with a minimum of supervision. C-6422.

Construction Engineer and Superintendent; Jun. Am. Soc. C.E.; 30; single; graduate; 6 years experience surveys, design, building construction. Qualified to estimate, organize, and completely handle job in the field. Desires position with consulting engineer or general contractor. D-2305.

Construction or Surveys; Assoc. M. Am. Soc. C.E.; C.E., Princeton, 1922; 32; single; 10 years varied experience; 8 years on all types of railroad construction, maintenance, and surveys. Especially qualified for layout and supervision of construction, and design of track layouts. Experienced in handling survey parties. Careful, accurate, hard worker. D-1027.

Superintendent of Construction; M. Am. Soc. C.E.; experienced in bakery and brewery construction, handling all physical problems for either the owners or contractors; able to take complete charge. C-7840.

Construction Engineer and Superintendent; Assoc. M. Am. Soc. C.E.; 33; married; 13 years experience engineering construction includes hydro-electric, water supply, industrial plant construction and surveys; last 4 years harbor development construction, San Francisco Bay area, includes wharves, warehouse, sea walls, dredging, borings, hydrographic surveys. Prefers Pacific Coast. Available immediately. D-2322.

Design

Structural Engineer; M. Am. Soc. C.E.; 39; Michigan graduate; Pennsylvania license; 16 years experience design and construction of buildings and miscellaneous structures; 3 years teaching experience. Available immediately. B-6157.

Civil and Industrial Engineer; M. Am. Soc. C.E.; graduate; licensed; over 20 years experience design, construction, rehabilitation industrial plants of all kinds, hydro-electric developments, housing groups, commercial garages. Thoroughly competent in the supervision and direction of office and field forces, obtaining bids, purchase of materials. B-2835.

Structural Engineer; Assoc. M. Am. Soc. C.E.; licensed, Pennsylvania; married; 2 years detailing and design, building; 4 years marine engineering, structural; 12 years subway design, of which 3 years were in responsible charge of work; available immediately. D-2321.

Structural Designer; Assoc. M. Am. Soc. C.E.; 34 years old; college graduate; married; 10 years experience with fabricators and railroads in designing, estimating, and detailing of heavy bridges, mill and office buildings. Desires any suitable position, and will consider sales work. Location immaterial. A-3840.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 28; married; civil engineer's degree, Polytechnic Institute of Brooklyn; special course structural engineering; 9½ years practical experience in structural steel design for subways, piers, pier sheds, tunnels, buildings in railroad yards and elevated structures. Checker of shop drawings; excellent draftsman. Available immediately. Location anywhere. D-1754.

STRUCTURAL ENGINEER; Assoc. M. Am. Soc. C.E.; 32; graduate; New York State license; 8 years experience in design and construction of large buildings and highway structures; recently in charge structural design of parkway structures, especially rigid-frame bridges. Desires position with consulting engineer or teaching. Available immediately. Location immaterial. C-9968.

STRUCTURAL DESIGNER AND SALES ENGINEER; M. Am. Soc. C.E.; 39; married; graduate C.E.; licensed; 18 years experience in structural designing, managing steel fabricating plant, and selling. Last 8 years head of consulting engineering office, specializing in structural designing for architects, owners, and contractors. Large acquaintance among architects and contractors in northern New Jersey. A-5489.

GRADUATE CIVIL ENGINEER; Jun. Am. Soc. C.E.; 31; licensed P.E. and L.S.; 8 years experience; 6 years responsible charge as squad boss or assistant engineer; in charge of design of subsurface structures, preliminary surveys, construction, and estimates. Desires a position with a general contractor or municipality as public works engineer. Location East preferred. B-9499.

EXECUTIVE

EXECUTIVE; Jun. Am. Soc. C.E.; licensed professional engineer; member of New York Bar; graduate of Manhattan and of Fordham Law School; age 28. Experience: instructor in engineering at Manhattan; design and valuation, New York Central Terminal; valuation and estimating with architect; practice of law, real estate, and contractor's liens. Situation desired with executive department. C-3265.

EXECUTIVE; Assoc. M. Am. Soc. C.E.; civil engineer; 34. Registered professional engineer. Graduate University of Pennsylvania; 10 years experience. Sales organization and promotion. Consultation, planning, and construction industrial buildings. Protestant. Married. Speaks Spanish. Present salary, $5,000 plus expenses. Available about August 1. C-3604.

SANITARY ENGINEER; Assoc. M. Am. Soc. C.E.; expert on stream pollution, sewage and industrial wastes disposal; 10 years experience with largest disposal project in U.S., also sales promotion and reports on new developments with private corporation, qualified to investigate, study, report, design, operate, or take charge. D-1161.

ENGINEER; Assoc. M. Am. Soc. C.E.; technical education; 20 years experience; licensed New York; certificate National Bureau Engineering Registration. Design, construction, maintenance, executive, sales. Power and industrial plants, steel structures, railroad and contractors equipment, conveying and storage plants. B-4537.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 32; professional engineer licensed New York State; C.E. and B.S. degrees; 10 years varied experience in construction on New York City subway work. Will consider any position connected with engineering. B-7933.

ENGINEER; M. Am. Soc. C.E.; 25 years experience direct charge and supervision construction of railways, bridges, buildings, and other structures including surveys, in U.S. and foreign countries, costing over one hundred million dollars. Expert on concrete, foundations, winter construction, investigations. Fluent knowledge of French. Excellent references. Available anywhere. B-1476.

MUNICIPAL AND SANITARY ENGINEER; Jun. Am. Soc. C.E.; 31; married; 2 years assistant city engineer; 2 years large consulting firm, designing and supervising construction of water works, sewers, and sewage treatment plants; 2 years engineering accountant. Graduate Michigan University; M.S. degree, Municipal and Sanitary Engineering; licensed two states. Location immaterial. D-700.

EXECUTIVE, ENGINEER MANAGER; M. Am. Soc. C.E.; 47; married; licensed Pennsylvania. Experienced directing construction bridges, foundations, sewerage, water facilities, etc. Several years making up competitive bids on public and commercial projects, coordinating and expediting subcontracts, sales promotion and development of mechanical ideas; 14 years chief construction executive, two large organizations. Location, East. D-2285.

STRUCTURAL ENGINEER; Assoc. M. Am. Soc. C.E.; 34; graduate from Oregon State College in 1926; B.S. in C.E.; 8 years of design and drafting of steel framing, reinforced concrete and timber structures; cellulose plants design and construction. Any professional work will be accepted. Will go abroad. Speaks Russian. Available now. D-119.

CIVIL ENGINEER; M. Am. Soc. C.E.; graduate Delft, Holland; 49; licensed New York; 9 years responsible charge construction tunnels and bridges; 3 years railroad maintenance, track work, and design; 5 years inspector 300 railroad structures; 10 years responsible charge material testing and inspection for 500 million dollar construction. D-2255.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 31; married; licensed professional engineer, New York State; C.E. degree; 8 years general engineering practice including surveying, topography, and construction; assistant in charge of drafting room for municipal highway department. Desires engineering position. Available immediately. D-2315.

JUNIOR

ENGINEER; Jun. Am. Soc. C.E.; 23; single; B.S. in C.E.; experience with the Pennsylvania Department of Highways as inspector; gas service inspector for the Philadelphia Gas Works; experience on pneumatic caisson foundations; with the Pennsylvania Railroad on electrification from New York to Philadelphia; and some experience in automotive work. Location immaterial. D-2295.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 29; B.C.E. from Louisiana State University; Louisiana state licensed; 10 years experience, field and office work, in engineering department of Southern Pacific Railroad and construction department of Louisiana Highway Commission. Good draftsman. Available now. Location anywhere. D-2277.

ASSISTANT CIVIL ENGINEER; Jun. Am. Soc. C.E.; 24; single; B.S. and C.E.; 2 years assistant engineer, field and office investigation, survey and preliminary design flood control and water supply projects; 2 years private surveys, computations and construction; 3 months, state highway; 2 years instructor in evening college. Good references. Working or teaching position. D-2248.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; Cornell University, C.E.; 26; single; 5 years with general contractor as field engineer and assistant-superintendent in charge of subway, sewer, pipe, and utility lines, building construction. Good office man on estimates, design, drafting. Best references. Location anywhere. Salary open. C-6070.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; B.S. in C.E., Manhattan College, 1932; little experience in field during summer vacation; location immaterial; available immediately. D-2310.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 26; B.S. in C.E., New York University, 1930; 4 years sub-river tunnel construction. Assistant engineer with general contractor. Estimating, chief of party, river surveys, settlement levels, drafting, inspection, design, all work and studies incidental on tunnels for new city subway, also Holland Tunnel. Desires work, preferably with contractor. D-1921.

SALES

SALES MANAGER AND STRUCTURAL ENGINEER; Assoc. M. Am. Soc. C.E.; 39; married; graduate; high-class sales executive with long experience in sales and structural engineering, specializing in steel requirements for bridges and buildings. Seeking connection with building material manufacturer or general contractor. Qualified district sales manager. Good designer and estimator. Available soon. D-16.

STRUCTURAL SALES; M. Am. Soc. C.E.; 46; married; held responsible positions with steel fabricating companies in engineering and sales; well acquainted in Pittsburgh and Cleveland districts. Desires opportunity to communicate further information in detail. C-5095.

TEACHING

GRADUATE CIVIL ENGINEER; Jun. Am. Soc. C.E.; single; 22; B.S. cum laude (Yale); M.S. (Columbia); Sigma Xi; Reserve Officer, Corps of Engineers; desires position as structural engineer, either field or office, or teaching. Special ability in mathematical analysis and design. Location and salary immaterial; available immediately. D-2253.

INSTRUCTOR OR ASSISTANT PROFESSOR IN CIVIL ENGINEERING; Jun. Am. Soc. C.E.; Mem. S.P.E.E.; B.S. degree in C.E.; 2 years surveying and construction experience; 4 years successful experience teaching civil engineering in state university. Location immaterial. C-4719.

RECENT BOOKS

New books of interest to Civil Engineers, recently donated by the publishers to the Engineering Societies Library, will be found listed here. A comprehensive statement regarding the service which the Library makes available to members is to be found on page 87 of the Year Book for 1933. The statements made regarding the books are taken from the books themselves, and this Society is not responsible for them.

ATM—ARCHIV FÜR TECHNISCHES MESSEN. Lieferung 19 and 20, January and February 1933. Munich and Berlin, R. Oldenbourg. pp. 1–30, illus., diagrs., charts, tables, 12 × 9 in., paper, 1.50 rm. each.

Concise summaries by experts, on colorimetric hydrogen-ion determinations, the measurement of losses in mercury rectifiers, recording devices for instruments, watch movements, liquid gages, thermo-elements, and various other methods of measurement.

DESIGN OF SIMPLE STEEL STRUCTURES. By C. T. Morris. 4 ed. New York and London, McGraw-Hill Book Co., 1933. 279 pp., illus., diagrs., tables, 9 × 6 in., cloth, $2.50.

Since 1909, when Professor Morris published his *Designing and Detailing of Simple Steel Structures*, many advances have been made in methods of design, and changes in traffic and specifications have taken place. The present publication treats in one volume both the calculation of stresses in, and the design of, simple steel structures.

ELEMENTS OF INDUSTRIAL HEAT. Vol. I. By J. A. Randall and J. W. Gillon. New York, John Wiley & Sons, 1933. 261 pp., illus., diagrs., charts, tables, 9 × 6 in., cloth, $2.75.

A textbook presenting the fundamentals of heat engineering with a minimum of mathematical discussion. It deals with the fundamental concepts, calorimetry, expansion and changes of state caused by heat, heat transmission, fuels and combustion, air and humidity. There is a final chapter on the elements of thermodynamics.

GENERAL INDEX TO THE FINAL REPORTS OF THE PRESIDENT'S CONFERENCE ON HOME BUILDING AND HOME OWNERSHIP. Edited by J. M. Gries and J. Ford. Washington, President's Conference on Home Building and Home Ownership, 1933. 114 pp., 9 × 6 in., cloth, apply.

This volume consolidates the indexes of the 11 volumes of final reports and overcomes the differences in terminology that confront users of the separate indexes. It enables one to locate quickly all the material on topics that are discussed in several of the reports.

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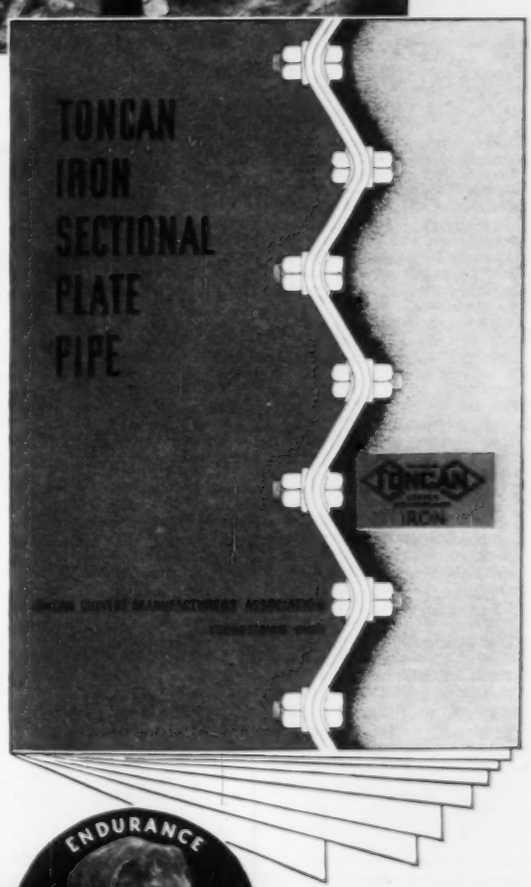

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BRIDGES

COMBINED, DENMARK. Combined Highway and Railway Bridges Across Storstrom and Masnedsund. *Engineering*, vol. 135, no. 3512, May 5, 1933, pp. 497 and 498. Bridge between Masned and Falster, 2 miles long, which will consist of 50 spans; stiffening girders are single-web plate girders; bridge across Masnedsund will consist of six 100-ft spans; one is an opening span of the fixed trunnion bascule type; two main girders of each span are plate girders. See also Engineering Index, 1932, p. 142.

CONCRETE, DESIGN. Reinforced Concrete Bridges of Very Great Spans, T. J. Guerrite. *Liverpool Eng. Soc.—Bul.*, vol. 6, no. 9, May 17, 1933, pp. 17–22 and 26. Notable examples o large-span concrete bridges; influence of transverse reinforcement or reinforcement consisting of two series of parallel wires connected by semi-circular parts and perpendicular to each other.

CONSTRUCTION. Building of Large Bridges. *Civ. Eng. (Lond.)*, vol. 28, no. 322, April 1933, pp. 152–156. A review of recent bridge projects in all parts of the world.

DESIGN. Bridge Design, C. S. Chettoe and H. C. Adams. *Roads and Road Construction*, vol. 11, no. 124, April 1, 1933, pp. 112–115. Simplified method of obtaining influence lines for analysis of a 2-hinged arch, based on first principles and applying to both steel and reinforced concrete arches having hinges at springings.

ECONOMICS. Low-Cost Bridges, S. B. Slack. *Am. Highways*, vol. 12, no. 2, April 1933, pp. 15–18. Bridge economics; operating cost; renewal charge; maintenance costs; insurance; low-cost designs; local materials.

HIGHWAY. New Type of Road Bridge, A. W. Knight. *Commonwealth Engr.*, vol. 20, no. 9, April 1, 1933, pp. 267–269. Methods of design and construction of a short-type span highway bridge consisting of a concrete slab deck resting on steel joists.

MODERN. Evolution of Modern Bridge, W. H. Wheeler. *Minn. Federation Arch. and Eng. Soc.—Bul.*, vol. 18, no. 5, May 1933, pp. 3–7. A review of methods of bridge design and construction, with special reference to Minnesota bridges.

NEW ORLEANS. Mississippi River Bridge at New Orleans. *Ry. Age*, vol. 94, no. 19, May 13, 1933, p. 700. Combined bridge 3,525 ft long built under the direction of the Public Belt Railroad Commission and financed by the Reconstruction Finance Corporation will be a double-track structure with a roadway on each side; through-truss cantilever structure, 1,850 ft long, consists of main span 790 ft long and two anchor arms, 530 ft each.

PENNSYLVANIA. Low-Cost I-Beam Bridges for Pennsylvania Highways. *Eng. News-Rec.*, vol. 110, no. 22, June 1, 1933, pp. 709 and 710. Replacement practice of the State of Pennsylvania; all-welded structures replace hundreds of weak bridges inherited from counties; original temporary design evolves into permanent type.

PLATE GIRDER, DENMARK. Storstrom Bridge. *Engineer*, vol. 155, no. 4035, May 12, 1933, p. 483. Further details of bridges, which will form a direct connection between the islands of Falster and Zealand; Storstrom Bridge is to have 50 spans; approach spans are deck spans of the cantilevered type, with suspended spans and anchor arms in alternate openings; main plate girders are 12 ft deep over flange angles and 24 ft apart, while cross girders are 3 ft deep spaced at 14 ft 6 in.-centers.

RECONSTRUCTION. Reconstruction of Kotri Bridge, Northwestern Railway of India. *Ry. Engr.*, vol. 54, no. 639, May 1933, pp. 138–140. Duplication of the main girders of the steel-truss railroad bridge over the Indus River at Kotri, consisting of 5 spans 360 ft long, each; in its present condition the bridge can take the latest standard of railroad loading and also carry cantilever roadways.

STEEL, WELDING. Welded Bridge Truss, R. E. Burt. *Rensselaer Polytechnic Inst.—Eng. and Science Series*, no. 40, Feb. 1933, 20 pp. Design of welded Warren truss with subverticals for the skew bridge of the Westinghouse Electric and Manufacturing Company, on their property at Chicopee Falls, Mass.

VIADUCTS, STEEL. High-Level Bridge Offers Comparison of Three Methods of Steel Erection. *Construction Methods*, vol. 15, no. 5, May 1933, pp. 26–32. A comparative study of various methods used in the erection of the superstructure of the 3½-mile viaduct, recently constructed by the New Jersey State Highway Commission across the meadows between Newark and Jersey City.

WELDING. Bridge Welding Practices in Australia, W. T. B. McCormack. *Eng. News-Rec.*, vol. 110, no. 19, May 11, 1933, pp. 596–598. Practice in the erection of several structures of respectable size built in Victoria, Australia; procedure characterized by the use of covered electrodes and multiple-run beads.

WIDENING. Widening Highway Bridge Decks in Mississippi, C. Simmons. *Eng. News-Rec.*, vol. 110, no. 22, June 1, 1933, pp. 710 and 711. Practices of the Mississippi highway department; by constructing a new and wider slab on top of the old slab of concrete deck structures, economy and speed are attained; steel spans widened by substituting deck girders for pony trusses; cost data.

WOODEN. Treated Timber Makes Good Record in M. & O. Railroad Bridges, H. Austil. *Eng. News-Rec.*, vol. 110, no. 21, May 25, 1933, p. 681. Examples of the life of treated timbers in the railroad bridges of the Mobile and Ohio Railroad. Before Am. Wood Preservers' Assn.

BUILDINGS

EARTHQUAKE EFFECTS. Earthquake Damage Analyzed by Long Beach Officials, C. D. Wailes, Jr., and A. C. Horner. *Eng. News-Rec.*, vol. 110, no. 21, May 25, 1933, pp. 684–686. An official report of the damage caused in Long Beach by the earthquake of March 10, 1933; relation between the number of damaged and undamaged buildings; "old code" structures were most vulnerable; basic code changes suggested for existing as well as for future buildings.

OFFICE BUILDINGS, DESIGN. Newspaper Building Floor Designed for 2,100-lb. Load, W. A. Lensky. *Eng. News-Rec.*, vol. 110, no. 19, May 11, 1933, pp. 586–588. Features of the new Times-Star Building in Cincinnati, supported with pipe-pile foundations; 17-story office section insulated from the 6-story printing section, on one floor of which provision has been made for a 2,100-lb live load.

PARTITIONS. Steel Partitions—Present and Future Possibilities, J. G. Mapes. *Metal Progress*, vol. 23, no. 6, June 1933, pp. 20–22. Notes on the use of metal as a material for the interior partitions of offices and industrial buildings; methods used by Mills Company of Cleveland; furniture grade sheet formed into sub-units and crimped and snapped together build up rigid metal partitions.

STEEL, ELECTRIC WELDING. Milwaukee's First All-Welded Building, A. S. Fredrickson. *Welding*, vol. 4, no. 5, May 1933, pp. 206 and 207. Construction by the Lakeside Bridge and Steel Company, Milwaukee, Wis., of Milwaukee Hospital addition, designed for welding to eliminate noise and to effect economy; addition is L-shaped, irregular, approximately 115 by 135 ft.

CONCRETE

CONSTRUCTION, FORMS. Stationary Forms for Bin Walls, L. B. Mercer. *Concrete and Constr. Eng.*, vol. 28, no. 5, May 1933, pp. 310–320. Design construction and costs of stationary formwork for circular bins; advantages of construction with stationary forms.

DAMS, CONCRETE GRAVITY, CALIFORNIA. Concreting at Pine Canyon Dam. *Eng. News-Rec.*, vol. 110, no. 21, May 25, 1933, pp. 671–674. Layout, equipment, and control of a plant for placing 440,000 cu yd of mass concrete in a curved gravity dam 240 ft high; vibrators place "no-slump" mix deposited by 4-yd buckets; low-heat cement cuts maximum concrete temperature about 20 deg.

DESIGN. Réflexions sur le béton armé, A. Chaulet. *Technique des Travaux*, vol. 9, no. 4 April 1933, pp. 237–246. Discussion of certain properties of concrete affecting the design of concrete structures; effect of temperature variations and shrinkage; nature of stresses in concrete. (To be continued.)

MIXING. Economical Mixes of Concrete, G. H. Hargreaves. *Concrete and Constr. Eng.*, vol. 28, no. 5, May 1933, pp. 287–291. Rich versus poor mixes; calculation of quantities; cost quantities in beams.

PLASTICITY. Rheological Properties of Cement and Cement-Mortar-Stone, E. C. Bingham and M. Reiner. *Physics*, vol. 4, no. 3, March 1933, pp. 88–96. Study of the deflections of beams of cement-stone and cement-mortar stone with a ratio of cement to sand of 1:3 allowed to bend under their own weight, leading to the conclusion that for all practical purposes, cement-mortar stone may be regarded as solid of very low rigidity and cement-stone as very viscous liquid; determination of the law of elasticity for cement and cement mortar; calculation of maximum stress in beam under dead load.

RESERVOIRS. Boughton Reservoir of Chester Water Works Company. *Engineering*, vol. 135, no. 3515, May 26, 1933, pp. 576–578. Capacity of reservoir is 9,367,500 gal; foundations are partly in clay and partly in sand; reservoir is constructed in reinforced concrete, the reinforcement consisting of rolled steel sections strengthened by round steel bars, arranged so as to form a rigid structure; system patented by H. C. Ritchie and Partners.

CONSTRUCTION INDUSTRY

CALIFORNIA. Unit Bid Summary. *West. Construction News and Highways Bldr.*, vol. 8, no. 8, April 24, 1933, pp. 208–211. Unit costs bid on street and road work and tunnel construction in California.

COSTS. Unit Bid Summary. *West. Construction News and Highways Bldr.*, vol. 8, no. 9, May 10, 1933, pp. 250 and 252. Unit costs bid on street and road work, bridges, and culverts in California and Colorado.

CURRENT PRICES. Current Construction Unit Prices. *Eng. News-Rec.*, vol. 110, no. 19, May 11, 1933, p. 608. Unit prices bid on timber wharf, Albany Port District; dredging, Niagara River East Channel; concrete bridge and earth-dam, Michigan; and Lock No. 1, Barren River, Kentucky.

DAMS

CABLEWAYS. Cableways at Hoover Dam Site, W. R. Nelson. *Reclamation Era*, vol. 24, no. 5, May 1933, pp. 58–60. Description of five 20-ton cableways of 2,575-ft maximum span and one 150-ton cableway.

CALIFORNIA. San Gabriel Rock-Fill Dams No. 1 and 2, A. G. Darwin. *West. Construction News and Highways Bldr.*, vol. 8, no. 9, May 10, 1933, pp. 241–246. Construction of dam embankments and outlet tunnels of rock-fill dams 310 and 255 ft in height.

CONCRETE. L'emploi de coffrages glissants, systeme MacDonald, pour la construction des murs de barrages. *Genie Civil*, vol. 102, no. 19, May 13, 1933, pp. 449–451. Use of sliding forms in the construction of concrete sluice gate dams.

CONCRETE GRAVITY, CONSTRUCTION. Pine Canyon Water Supply Dam for Pasadena. *West. Construction News and Highways Bldr.*, vol. 8, no. 9, May 10, 1933, pp. 237–240. Methods of construction—with emphasis on concrete placing—for Pine Canyon Dam, which has a

maximum height of 325 ft above the lowest foundation.

EARTH FILL, CALIFORNIA. Bouquet Canyon Reservoir and Outlet Works. *West. Construction News and Highways Bldr.*, vol. 8, no. 9, May 10, 1933, pp. 226–230. Construction of Los Angeles Water Bureau reservoir, including two earth-fill dams, up to 222 ft in height, concrete dike, spillway shaft and tunnel, outlet tunnel and conduit, and relocated section of county road at a total cost of $4,000,000.

FRANCE. Le barrage de Suresnes, R. Godon. *Technique des Travaux*, vol. 9, no. 4, April 1933, pp. 218–229. Description of a recently completed sluice-gate dam, at Suresnes; maximum height to full supply level is 7 m; steel gate of MAN manufacture has a span of 30.5 m; sluice operating equipment.

HOOVER (BOULDER) DAM PROJECT, CONSTRUCTION. Construction Progress on Hoover (Boulder) Dam, W. R. Nelson. *West. Construction News and Highways Bldr.*, vol. 8, no. 9, May 10, 1933, pp. 218–222. Summary of a series of articles by the same author previously indexed from various sources.

RESEARCH. Research Work of Bureau of Reclamation, E. Mead. *Reclamation Era*, vol. 24, no. 5, May 1933, pp. 54, 55, and 57. Review of the research in connection with the design and construction of Boulder Dam, particularly matters pertaining to concrete mixing and placing. (To be continued.)

ROCK FILL, CALIFORNIA. San Gabriel No. 2—a Rock-Fill Dam of Unusual Interest, W. A. Sawdon. *Excavating Engr.*, vol. 27, no. 5, May 1933, pp. 183–188 and 208. Construction of rock-fill dam 255 ft high and 750 ft long; spillway excavation; flexible gunite facing of upstream surface of dam; quarry equipment; performance of construction machinery.

FLOOD CONTROL

RESERVOIRS. I serbatoi di piena, F. Marzolo. *Energia Elettrica*, vol. 10, no. 4, April 1933, pp. 269–284. Theory of flood detention reservoirs and a survey of practices in Europe and the United States.

FOUNDATIONS

RETAINING WALLS, DESIGN. Piled Retaining Wall Sections, W. S. Wilson. *Surveyor*, vol. 83, no. 2156, May 19, 1933, pp. 527–530. Practical examples of the design of a combination of piling with L-shaped counterforted reinforced concrete retaining walls.

HYDRO-ELECTRIC POWER PLANTS

GREAT BRITAIN. Lochaber Water Power Scheme. *Engineer*, vol. 155, no. 4036, May 19, 1933, pp. 492–495. Map of district in Scotland covered by scheme indicating the positions of dams and tunnels; progress being made in connection with second-stage works; dredging of river Spean; construction of Laggan Dam; Laggan-Treig Tunnel; Treig Dam and railway diversion.

TENNESSEE RIVER. Power on Tennessee River. *Eng. News-Rec.*, vol. 110, no. 19, May 11, 1933, pp. 579–583. Government plan for development of an additional 693,000 kw in the basin of the Tennessee River; navigation and flood control problems; review of development to date.

HYDROLOGY, METEROLOGY, AND SEISMOGRAPHY

SNOW SURVEYS, RUN-OFF. Predicting Run-off by Snow Surveys. *Electrical West*, vol. 70, no. 5, May 1, 1933, pp. 149–151. Possibility of accurate predetermination of stream-flow characteristics from study of snowfall; the state cooperates with other agencies in compiling data for major California watersheds.

IRRIGATION

UNITED STATES. Irrigation Work in Indian Bureau. *Eng. News-Rec.*, vol. 110, no. 22, June 1, 1933, pp. 712–714. Review of irrigation construction and practice in Indian reservations within a radius of 600 miles of Salt Lake City, Utah: Wapato project; silt problem on San Carlos project; minor projects.

LAND RECLAMATION AND DRAINAGE

CANALS, LINING. Flexible Lining of Tile Used for Drainage Ditch. *Eng. News-Rec.*, vol. 110, no. 19, May 11, 1933, p. 585. Paving of Cedar Fork Creek at Galesburg, Ill., carrying sanitary and storm sewage flow, with vitrified tile blocks, for a length of 3½ miles; tongue and groove liner blocks are staggered in such a manner that ½-in. steel bars in holes fasten each block to two adjacent blocks on either end.

ITALY. De drooglegging der Pontijnsche moerassen, M. de Jongh. *Ingenieur*, vol. 47, no. 48, Nov. 25, 1932, pp. B247–255 (discussion) B255–258. Drainage and reclamation of the Pontine marshes, on the west coast of Italy, south of Rome; history of the region; construction methods; design of drainage canals.

MATERIALS TESTING

BUILDING MATERIALS, WEATHERING. Zur Frage des zeitliche Ablaufes von Witterungseinfluessen auf Bauwerke, R. Grengg. *Bauingenieur*, vol. 14, nos. 9 and 10, March 3, 1933, pp. 117–122. Observations on passing and permanent effects of heat, frost, and other weather factors on masonry surfaces.

CEMENT TESTING. Ueber Zementauswahl fuer Betonbauten, E. Rissel. *Bauingenieur*, vol. 14, nos. 7 and 8, Feb. 17, 1933, pp. 102–106. An outline of tests for determining the most suitable cement for a given concrete mixture.

PORTS AND MARITIME STRUCTURES

BREAKWATERS, CALIFORNIA. Long Beach-Los Angeles Harbor Breakwater, W. S. Howard, Jr. *West. Construction News and Highways Bldr.*, vol. 8, no. 9, May 10, 1933, pp. 231–233. Construction of a 1,400-ft section of rubble-mound enrockment forming part of a composite-type breakwater in the Los Angeles and Long Beach harbors in San Pedro Bay; enrockment has earth core.

DOCKS, BIRKENHEAD, ENGLAND. Dock Extension at Birkenhead. *Engineering*, vol. 135, no. 3512, May 5, 1933, p. 498; see also *Engineer*, vol. 155, no. 4034, May 5, 1933, p. 540. Bidston Dock is 1,000 ft long and has a mean width of 400 ft; the work of excavation was carried out by constructing a temporary dam across the entrance and driving piles on which retaining walls were built well down into underlying clay.

SOUTHAMPTON. Southampton Docks Extensions. *Civ. Eng. (Lond.)*, vol. 28, no. 322, April 1933, pp. 130 and 131. Progress report on the construction of extensions, including sheds; description of dredging operations.

ROADS AND STREETS

ACCIDENT PREVENTION. Some Safety Problems of Road Engineer, W. H. Morgan. *Surveyor*, vol. 83, no. 2157, May 26, 1933, pp. 545 and 546. Review of safety measures for conditions of direct traffic flow; that is, channel flow, junctions or transverse traffic flow, and non-vehicular traffic (pedestrian). Before Nat. Safety Congress.

BITUMINOUS. Something New in Road Surfacing Technique, R. G. Wace. *Contract Rec.*, vol. 47, no. 21, May 24, 1933, pp. 503–505. Characteristics of a new bituminous emulsion known as "terolas," evolved by Colas Products, Ltd., of London, presenting special merits for low-cost construction.

BRICK. Brick Resurfaced with Concrete on Iowa Paving Project. *Construction Methods*, vol. 15, no. 5, May 1933, pp. 22 and 23. Experience with concrete resurfacing of 9,600 ft of old pavement on U.S. 55, north of Dubuque.

CANADA. Construction and Maintenance of Quebec Highway System. *Can. Engr.*, vol. 64, no. 22, May 30, 1933, pp. 11–16. Report on 1932 progress; present highway situation; types of pavement; main highway system; road maintenance in 1932; maintenance at Government expense; road improvements; permanent pavements program.

CONCRETE. Grading and Paving Ridge Route Alternate. *West. Construction News and Highways Bldr.*, vol. 8, no. 9, May 10, 1933, pp. 223–225. Construction of 27 miles of 30-ft cement concrete pavement between the Castaic School and Gorman, Los Angeles County; total cost $3,400,000; contract quantities and prices for grading.

CONSTRUCTION. Promoting Safety in Highway Construction, H. D. Immel. *Roads and Streets*, vol. 76, no. 5, May 1933, pp. 187–189. Accident prevention policies of the Pennsylvania Department of Highways; department purchases 24,000 pairs of safety goggles; device developed in driving posts; safety education; first-aid instructors; accident records; use of accident reports; set-up of safety organization.

CURVES. Analysis of Camber and Superelevation on Road Curves, H. C. Platt. *Surveyor*, vol. 83, no. 2154, May 5, 1933, pp. 485 and 486. Review of principles of design. Before Inst. Civ. Engrs.

DESIGN. Making the Highway Pay for its Cost, B. E. Gray. *Eng. News-Rec.*, vol. 110, no. 19, May 11, 1933, pp. 590 and 591. Construction of chart for ascertaining justifiable capital outlay per mile and type of improvement indicated for any highway project; stage construction; overbuilt roads.

EARTHQUAKE EFFECTS. Quake Damage to Highways Slight; Mostly Confined to Tideland Fills, S. V. Cortelyou. *Calif. Highways and Pub. Works*, vol. 11, no. 4, April 1933, pp. 2, 3, 10, and 24. Survey of damage to roads, bridges, and other highway structures caused by the earthquake of March 10, 1933, in the district of Los Angeles and Long Beach, Calif.

EXPERIMENTAL. Experimental Salt-Clay-Gravel Road, G. D. MacDougall. *Can. Engr.*, vol. 64, no. 22, May 30, 1933, pp. 19 and 20. Results of experiments with salt surfacing treatment on a road at Elmsdale, N.S.

FINANCING. Source and Application of Highway Dollar, H. R. Trumbower. *Am. Highways*, vol. 12, no. 2, April 1933, pp. 5–7 and 18 and 19. Financing of Wisconsin highways; street and highway expenditures by counties; sources of funds to meet highway and street expenditures; contribution by residents of towns and cities; motor vehicle mileage traveled; comparison of percentage of travel and expenditures by residents of towns, villages, and cities; highway expenditures per mile of travel.

MACADAM. New Glencoe Road, W. H. Hunt. *Surveyor*, vol. 83, no. 2154, May 5, 1933, pp. 473–475. Description of the recently completed road leading from Glencoe Village to Tyndrum, Scotland; 30.3 miles long; 18 ft wide; surfaced with bituminous or water-bound macadam; features of highway bridges. Before Inst. Mun. and County Engrs.

MACHINERY. WELDING. Road Contractor Uses All-Welded Equipment, J. C. Coyle. *Welding*, vol. 4, no. 5, May 1933, pp. 215–218. Welding used in the repair and maintenance of road equipment including trailers, premixing plant, portable drying unit, and dump-truck bodies.

MAINTENANCE AND REPAIR. About Roadway Stability Using Calcium Chloride, H. F. Clemmer. *Roads and Streets*, vol. 75, no. 5, May 1933, pp. 184–186. Roadbed stability; function of soil "glue"; experimental work; losses of material; action following rains; obtaining and measuring stability. Before 1933 Road School at Purdue University.

MATERIALS. ASPHALT. What Are Cut-Back Asphalts and Why Are They Used? P. Hubbard. *Contract Rec.*, vol. 47, no. 21, May 24, 1933, pp. 499–502. Before the Tenth Annual Asphalt Paving Conference, previously indexed from Roads and Streets, January and February 1933.

SPECIFICATIONS. Report of Committee D-4 on Road and Paving Materials. *Am. Soc. Testing Materials—Advance Paper*, no. 58, meeting June 26–30, 1933, 14 pp. Recommendations affecting standards; proposed tentative specifications for concrete for pavements.

SANITARY ENGINEERING

CHICAGO, ILL. Water Supply, Sewerage, and Sewage Disposal in Chicago Metropolitan Area. *West. Soc. Engrs.—Journal*, vol. 38, no. 2, April 1933, pp. 102–106. Report to Civic Affairs Council, outlining general principles that should be followed in planning.

MUNICIPAL SANITATION. Mechanical Developments in Municipal Sanitation, W. Raisch. *Mech. Eng.*, vol. 55, no. 6, June 1933, pp. 363–368. Development of the art of municipal sanitation; sewage treatment and disposal; clarification; sterilization; flood disposal; mechanical apparatus in use; garbage and refuse disposal; burning on open dump; hog feeding; dumping at sea; reduction; and incinerator plants.

SEWERAGE AND SEWAGE DISPOSAL

ACTIVATED SLUDGE. New Method of Concentrating Activated Sludge, R. F. Goudey and S. M. Bennett. *Water Works and Sewerage*, vol. 80, no. 5, May 1933, pp. 179 and 180. Description of a process entailing the withdrawal of excess activated sludge to be taken out of the system in the form of mixed sewage and sludge from main aeration tanks; comparison of old methods with new.

BRITISH GUIANA. Main Drainage of Georgetown, British Guiana, G. H. Humphreys and I. M. E. Aitken. *Inst. Civ. Engrs.—Min. Proc.*, vol. 23, paper no. 4859, 1933, 52 pp., 1 supp. plate. Design and construction of the sewage disposal system of a tropical city, with a population of about 62,000; construction and testing of an electric sewage pumping plant.

CHEMICAL PROCESS. Chemical Treatment of Sewage as Adjunct to Sprinkling Filter Operation, J. R. Downes. *Water Works and Sewerage*, vol. 80, no. 5, May 1933, pp. 166 and 167. Method entailing the application of ferric iron coagulants to improve the operation and raise the efficiency of an overloaded sewage treatment plant. Before New Jersey Sewage Works Assn.

DISPOSAL PLANTS, OPERATION. Results of Three Years of Operation of Akron Sewage Works, A. B. Backherms. *Mun. Sanitation*, vol. 4, no. 5, May 1933, pp. 161–163. Comparison of design and actual performance; detritus-Imhoff filter installation; bar screens and detritus tanks; tanks operated at high and low levels; detritus pumps; grit channels and conveyor mechanism; grease bed operation data. (To be continued.)

EAST ROCHESTER, N.Y. Many Novel Features Incorporated in Village Sewage Treatment Plant, R. G. McDonald. *Mun. Sanitation*, vol. 4, no. 5, May 1933, pp. 152–155. Description of the new sewage treatment plant of East Rochester, N.Y., serving a population of about 70,000; details of two-story tank reinforced by welding; gas collection; heating of sludge digestion compartment; dosing device; laboratory control.

EQUIPMENT. Mechanical Equipment in Sewage Treatment Works—XII, A. P. Folwell. *Pub. Works*, vol. 64, no. 5, May 1933, pp. 11–13.

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General operation equipment; laboratory equipment; gas masks and gas detectors; supplementary notes to previous chapters.

EXPLOSIONS. Explosion and Health Hazards in Sewage Works Operation, G. W. Jones. *Sewage Works Journal*, vol. 5, no. 2, March 1933, pp. 289–301. Oxygen supply; ignition sources; distribution of oxygen with respect to combustibility; limits of inflammability; source of ignition; direction of flame propagation; diameter of explosion apparatus; length of test; ignition from closed end and turbulence; effect of temperature, pressure, and humidity; physiological effects of sewage gas; oxygen deficiency; flame traps. Before New York State Sewage Works Assn.

GERMANY. Biological Treatment Plant at Erfurt, Stade. *Sewage Works Journal*, vol. 5, no. 2, March 1933, pp. 354–356. English abstract of the paper indexed in Engineering Index 1932, p. 1176, from *Gesundheits Ingenieur*, Oct. 15, 1932.

MAINTENANCE AND REPAIR. Round Table. *Mun. Sanitation*, vol. 4, no. 5, May 1933, pp. 167, 168, and 170. A practical discussion of methods of cleaning sewers; frequency of cleaning sewers in business and residential districts; causes for sewage stoppage; discussion comparing methods and equipment.

MARYLAND. Meeting of Maryland-Delaware Water and Sewerage Association. *Water Works and Sewerage*, vol. 80, no. 6, June 1933, pp. 203–206. Proceedings of the 1933 annual meeting, including abstracts of the following papers: Stream Control in Maryland, F. H. Drydon; Cast-Iron Pipe and Fittings for Sewer House Connections, H. R. Devilbiss; Public Utilities in Small Towns, L. D. Shank; Filter Sand and Washing Experiences, C. J. Lauter; Cellar and Open Area Connections to Sanitary Sewers, Elwood Johnson; New Baltimore Garbage Incinerator, O. H. Schroedl; New Sewage Treatment Works of Wilmington, H. L. Maier; Forestation for Watershed Protection, F. W. Besley; Automatic Pumping Stations on Baltimore Water Supply Systems, L. Small; Sewage Treatment in Germany, S. L. Dorsey.

NEW YORK. Approach to City Saved by Sewage Works Design, Construction, and Operation of Saranac Lake Plant, H. W. Taylor. *Sewage Works Journal*, vol. 5, no. 2, March 1933, pp. 278–288. Design and operation of the sewage disposal system of Saranac Lake, N.Y., which has a population of 14,000; pumping station; office building; settling tanks; sludge tanks; sludge beds; screenings; tests of settling tanks; operation of settling tanks; sludge digestion; sludge liquor; digested sludge; general plant operation. Before New York State Sewage Works Assn.

OPERATION. Results of Three Years of Operation of Akron Sewage Works, A. B. Backherms. *Mun. Sanitation*, vol. 4, no. 6, June 1933, pp. 189–191. Removals by detritus units; plan of detritus structures; Venturi meters; Imhoff tanks; rubber wastes; operating cost; trickling filters. (To be concluded.)

SEATTLE, WASH. Freeing Lake Washington from Sewage. *Eng. News-Rec.*, vol. 110, no. 22, June 1, 1933, p. 714. Outline of a project to eliminate the discharge of sewage into Lake Washington which bounds the east side of Seattle, Wash.; interceptors and pumping plants will divert the flow from 29 small outfalls into Puget Sound; the plan will serve an area of more than 4,000 acres, will include 14 pumping plants, and will cost about $5,000,000.

SEWERS, CLEANING. Round Table. *Mun. Sanitation*, vol. 4, no. 6, June 1933, pp. 200–202. A practical discussion of the methods of cleaning sewers; chief causes of sewer stoppage; methods and equipment; frequency of cleaning sewers in business and in residential districts.

SEWERS, CONNECTIONS. Cast Iron Pipe and Fittings for Sewer Connections, H. R. DeVilbiss. *Water Works and Sewerage*, vol. 80, no. 5, May 1933, pp. 171–173. Before the Maryland-Delaware Water and Sewerage Assn., previously indexed from *Mun. Sanitation*, May 1933.

SLUDGE. Dewater of Sludge. *Surveyor*, vol. 83, no. 2156, May 19, 1933, pp. 525 and 526. Description of heated and covered filter at Aldershot Borough, England; sludge dewatering in covered type of filter of special construction, heated by means of steam pipes.

STRUCTURAL ENGINEERING

BEAMS, WOODEN. Wood-Beam Design Method Promises Economies, J. A. Newlin, G. E. Heck, and H. W. March. *Eng. News-Rec.*, vol. 110, no. 19, May 11, 1933, pp. 594–596. Tests and analyses made at the Forest Products Laboratory, Madison, Wis., show horizontal shear stresses to be lower than usually assumed, by virtue of the top and bottom halves of the beam acting as separate units; new design method takes this two-beam action into account; results of tests of built-up artificially checked spruce beams.

FLOORS, CONCRETE BEAMS. Pre-Cast Concrete Floor Beams. *Concrete and Constr. Eng.*, vol. 28, no. 5, May 1933, pp. 321–328. Floor elements developed by the Rapid Floor Company; the beams are laid side by side to form a cavity floor, the top flanges interlocking and forming a V-joint for grouting; method of manufacture.

RIVETED JOINTS, TESTING. Testing Riveted Joints of Cromansil Steel, I. Lyse. *Eng. News-Rec.*, vol. 110, no. 19, May 11, 1933, pp. 584 and 585. Lehigh University tests of riveted joints of plates made of newly developed low-alloy structural steel.

TUNNELS

CONSTRUCTION, CALIFORNIA. Hazardous Tunneling at Hetch Hetchy. *Eng. News-Rec.*, vol. 110, no. 22, June 1, 1933, pp. 701–704. Report on driving operations on the last section of the 28.6 miles of Coast Range tunnel, for the Hetch Hetchy water-supply system of San Francisco, Calif.; special methods for combatting gas hazard; sublining of pneumatically sprayed concrete replaces timbering in squeezing ground; ventilating system; light and power circuits; testing for gas and rescue work; operating cycle.

DRAINAGE TUNNELS. Notes on Tunnel Driven at Stan Trg Mine, Yugoslavia, D. I. Rogers. *Inst. Min. and Met.—Bul.*, no. 344, May 1933, pp. 39–45. Author's reply to discussion of paper indexed in Engineering Index 1932, p. 832, from issue no. 339, Dec. 1932.

WATER SUPPLY TUNNELS, BALTIMORE, MD. Baltimore Water Tunnel under City Streets. *Contractors and Engrs., Monthly*, vol. 26, no. 5, May 1933, pp. 13–17 and 30. Construction of water supply tunnel leading from an undeveloped filtration plant to Vernon pumping station in Druid Lake, a distance of 13,294 ft; shaft construction; equipment at top of shafts; tunneling operations; checking neat line; ventilation during work; mucking; tunnel drainage during construction; placing pipe; placing concrete pneumatically around pipe.

WATER RESOURCES

UNDERGROUND. Notable Improvements in Ground-Water Development, O. E. Meinzer. *Eng. News-Rec.*, vol. 110, no. 23, June 8, 1933, pp. 750–752. Review of hydrologic studies made by Federal and state agencies, allowing a rational design of ground-water supplies; advances in equipment design; better methods of well construction and pumping machinery; groundwater hydrology; ground-water investigations; quantitative studies; professional advice on ground-water projects.

WATER TREATMENT

ANALYSIS. Chemical and Biological Characteristics of Pacific Northwest Waters, H. W. Nightingale. *Am. Water Works Assn.—Journal*, vol. 25, no. 5, May 1933, pp. 740–746. Average chemical composition of the surface waters of the Washington and Oregon rivers; chemical analyses of ground waters of the Northwest; biological characteristics.

ALGAE CONTROL. Round Table. *Water Works Eng.*, vol. 86, no. 10, May 17, 1933, pp. 417–419. Uses of copper sulfate in water treatment; dosage; substitutes for copper sulfate.

CHLORINATION, AMMONIA-CHLORINE. Ammonia-Chlorine Process at Richmond, M. C. Smith. *Water Works and Sewerage*, vol. 80, no. 5, May 1933, pp. 157 and 158. Experience of the Bureau of Water and Electricity, of Richmond, Va., with chloramine.

HAMILTON, ONT. Canada's Latest and Most Modern Water Purification Works—40-mgd Filtration Plant at Hamilton. *Contract Rec.*, vol. 47, no. 12, March 22, 1933, pp. 282–287. Review of unusual features of design and equipment; low-lift pumping station; chemical building and mixing chambers; settling basins; filters; wash-water tower; filtered water reservoir; electric power; sewerage system; heating plant and pipe tunnels.

IOWA. Operation Experience at Cedar Rapids Water Purification Plant, H. F. Blomquist. *Am. Water Works Assn.—Journal*, vol. 25, no. 5, May 1933, pp. 711–717. History of water treatment in Cedar Rapids, Iowa, since 1896; report on operating experience comparing actual results obtained with theoretical or anticipated results.

MANGANESE REMOVAL. History of, and Methods for, Removal of Manganese in Water Supplies, C. Zapffe. *Water Works Eng.*, vol. 86, no. 9, May 3, 1933, pp. 365–367. Review of previous studies; period of catalysis (1922–1930); present practice (1930); pilot plant furnishes data for main unit. Bibliography. Before Am. Water Works Assn. (Concluded.)

MATERIALS. Use of Anthracite Coal as Filter Medium, M. A. Farrell. *Am. Water Works Assn.—Journal*, vol. 25, no. 5, May 1933, pp. 718–724. Checking previously published laboratory results by tests made in recirculation pressure filters of the Lehigh University swimming pool for comparing efficiency of bacterial removal of coal filters with former sand filters, both with and without auxiliary copper sulfate treatment; bacteriological analysis.

ONTARIO. What Are Prospects for Extension of Water Softening? E. W. Johnston. *Contract Rec.*, vol. 47, no. 12, Mar. 22, 1933, pp. 301–303. Survey of Ontario water supplies in which excess hardness might justifiably be corrected; lack of softening facilities; types of water softeners; domestic consumption of soap and amount wasted due to hard water; Ontario municipal water supplies having a hardness of 200 ppm or more.

SAMPLERS. Water Sampler Avoids Contamination by Air Bubbles, F. E. Daniels. *Eng. News-Rec.*, vol. 110, no. 22, June 1, 1933, p. 704. Original sampler constructed wholly of brass and copper, collecting four samples simultaneously directly in test bottles; air originally in sample bottle is displaced into container by entering water without causing bubbles at the mouths of bottles; air in container escapes by a tube through the lid.

SOFTENING. Water-Softening Practice Shows Rapid Growth, C. H. Spaulding. *Eng. News-Rec.*, vol. 110, no. 23, June 8, 1933, pp. 747 and 748. Review of progress during the past decade, with special reference to recarbonation, zeolite softening, and iron removal.

TASTE AND ODOR REMOVAL. Taste and Odor Control in Water Supplies, A. V. De Laporte. *Am. Water Works Assn.—Journal*, vol. 25, no. 5, May 1933, pp. 677–679. Experience of a Canadian community in controlling taste by application of ammonium sulfate.

WATER WORKS ENGINEERING

CANADA. Water Works Statistics. *Can. Engr.* (*Water Works Directory and Convention Issue*) March 28, 1933, pp. 91–122. Supply, pumps, purification, distribution, services, mains, meter rates, names of officials, and other reference data pertaining to several hundred Canadian communities.

EDUCATION. Training Men for Water Service, J. J. Hinman, Jr. *Water Works Eng.*, vol. 86, no. 12, June 14, 1933, pp. 582–585. Importance of delayed and careful selection; unfortunate effect of depression on personnel; unwise economies; reduction of chemical dose below minimum; divisions of water department work; college students; summer schools.

GREAT BRITAIN. Water Supply of London, A. Houston. *Water and Water Eng.*, vol. 35, no. 418, May 20, 1933, pp. 271–273. History of London water works; engineering and statistical data on methods of water treatment, including chlorination and sanitary control of system. Before Sanitary Inspectors' Assn.

HYDRANTS, PORTLAND, ME. Hydrant Pressure and Flow Survey at Portland, Me., L. R. Smith. *Water Works and Sewerage*, vol. 80, no. 5, May 1933, pp. 181 and 182. Procedure of testing and recording; ownership and conditions of hydrants. Before New England Water Works Assn.

JAPAN. Tokyo's Water Supply Project, W. H. Clarke, Jr. *Far East. Rev.*, vol. 29, no. 3, March 1933, pp. 107–114 and 143. Program of expansion of water works of Tokyo, Japan, including construction of a concrete-gravity dam, known as Ogochi Reservoir Dam; 154 m maximum height; features of new distribution reservoirs and filtration plants.

LEBANON, N.H. Reconstruction of Lebanon, N.H., Water Works, R. S. Holmgren. *New England Water Works Assn.—Journal*, vol. 47, no. 1, March 1933, pp. 52–60. Improving the water works of a town having a population of 6,000; expenditure amounting to $58,000.

ONTARIO. Statistical Survey of Ontario Water Works, A. E. Berry. *Contract Rec.*, vol. 47, no. 12, March 22, 1933, pp. 295, 296, and 309. Statistical data on population, number of water works systems, ownership and expenditure, sources of supply, water treatment.

PUMPING PLANTS, DESIGN. Economics of Water Pumping, G. B. Williams. *Engineer*, vol 155, no. 4035, May 12, 1933, pp. 469 and 470. Method of arriving at general expression for ratio of capacity of pump to diameter of main through which it delivers; investigations based on Indian figures.

SAFETY FACTOR. Factor of Safety—What Should It Be in Water Works System? W. W. Brush. *Water Works Eng.*, vol. 86, no. 11, May 31, 1933, pp. 478–480. Factor of safety in the light of the experience of the New York City water supply system; adequacy of sources of supply; purification of supply; insurance against interruption of supply.

SPRINGFIELD, ILL. Water Plant Being Built at Springfield, Ill., Involves Unique Method of Financing, R. E. McDonnell. *Water Works Eng.*, vol. 86, no. 11, May 31, 1933, pp. 483–485. Outline of the new Lake Springfield Project for a population of 300,000 at Springfield, Ill.; site recommended for proposed lake; acquiring the site; marginal development of lake; revenue from residential leases.

TANKS. Milwaukee Builds Welded Tank of 6,000,000-Gal Capacity. *Eng. News-Rec.*, vol. 110, no. 19, May 11, 1933, p. 589. Features of the largest welded tank yet built; welding practice.

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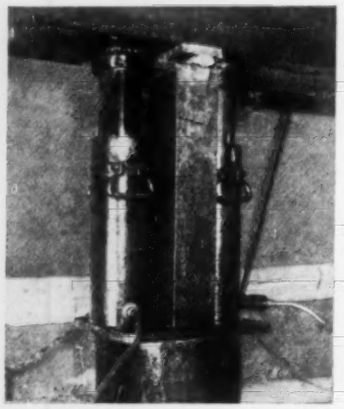

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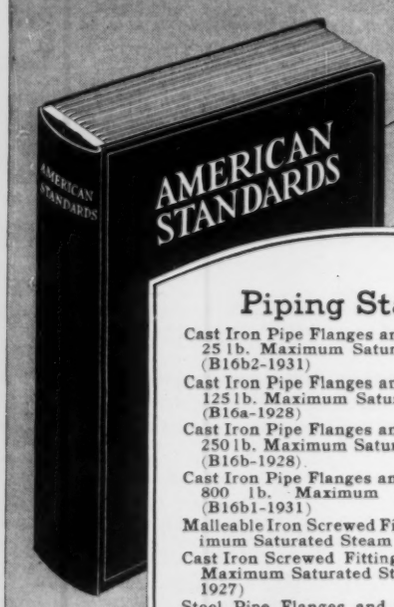

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